Educational Multimedia and Hypermedia, 1996
&
Educational Telecommunications, 1996

Proceedings of ED-MEDIA 96 & ED-TELECOM 96—
World Conference on
Educational Multimedia and Hypermedia
&
World Conference on
Educational Telecommunications
Boston, Mass., USA; June 17-22, 1996
PREFACE

It is our pleasure to welcome you to ED-MEDIA/ED-TELECOM 96. With over 300 presentations in 22 major areas, the conference offers a forum for the exchange of ideas and presentation of developments in the theory and practice of computers in education. We are especially fortunate this year to include as part of the program the World Conference on Educational Telecommunications.

This year’s gathering marks the 9th in a series of conferences dedicated to exploring the uses of advanced computer applications in education and training. The conference originated as the International Conference on Computers and Learning (ICCAL), and held four highly successful meetings: Wolfville, Nova Scotia (Canada 1992), Hagen (Germany 1990), Dallas, TX (USA 1989), and Calgary (Canada 1987). These well-attended meetings became the foundation for sponsorship by the Association for the Advancement of Computing in Education (AACE) in 1993. With this merger, the conference became an annual event and was enlarged in scope, holding meetings in Orlando, FL (USA 1993), Vancouver, BC (Canada 1994), and Graz (Austria 1995). With each successive year, the conference has grown, becoming the premier event for researchers and practitioners in the many disciplines that go into this rich and advancing field. Marking the 10th anniversary in 1997, the conference will return to the location of the first gathering, Calgary, Canada.

The major determining factor in the success of a conference is the people who make up the event. We take this opportunity to thank the various constituencies who have worked with us in the past year. We acknowledge the hard work of the Program Committee, who reviewed a record number of submissions, selected the program, and recruited the keynote and invited speakers. A special thanks goes to the Steering Committee—the “organizational memory” and guiding spirit of the conference—who provided sound advice both on policy and on day-to-day issues. Additionally, we offer thanks to everyone who submitted proposals and to all who are presenting. Without the tireless efforts and continued support of these individuals, the conference would not have achieved its remarkable growth and continued reputation for freshness of thought and consistent quality.

The conference would not be possible without sponsorship. We extend a heartfelt thanks to the AACE, especially to Dr. Gary Marks and his staff for the many, many hours they have contributed to making the conference possible. We also express our appreciation to the local hosts in Boston, who have worked to make our stay enjoyable.

We have before us a rich and stimulating week of activities. Please partake of all that the conference and its venue have to offer.

Patricia Carlson
Rose-Hulman Institute, USA
Fillia Makedon
Dartmouth College, USA
Full Paper-Award

Enhancing student learning by incorporating learning styles into adaptive hypermedia
Curtis A. Carver, Richard A. Howard & Edward Levelle

Off-campus preservice teacher education via IMM technology: An indigenous cohort case study
Lyn Henderson, Bill Patching & Ian Pott

The Impact of Learning Pathways on Performance in an Interactive Multimedia Learning Environment
Hueyching Janice Jih

Delivery methods for hypertext-based courseware on the World Wide Web
A.D. Marshall & S. Hurley

Experience with the Learning Web
M.L.G. Shaw & B.R. Gaines

Full Paper-Award Hon.

Efficacy of story in multimedia training
Daniel R. Bielenberg & Ted Carpenter-Smith

Experiences with learning scenarios in an authoring support environment
T.T. Carey & J.V. Minstrell

Instructional hypertext: Study strategies for different types of learning tasks
Diana Dee-Lucas

Designing and managing virtual learning environments for secondary, post-secondary, graduate and continuing education: A landgra
A.Hill Duin & E.A. Nater

The Flashlight Project: Developing tools for local assessment of educational strategies and technology
Stephen C. Ehrmann

The Web as a Student Communication Medium: What's Different?
Stephen Gilbert

Advanced collaborative educational environment using virtual shared space
Yasuhisa Kato, Akihisa Kawanobe, Susumu Kakuta, Katsumi Hosoya and Yoshimi Fukuhara

Improving WWW-Aided Instruction A Report from Experience
Samuel A. Rebelsky
**Full Paper-Student Award**

**Toward a software engineering discipline for the modelling and the design of hypermedia distributed applications**
Patrick Senac, Francois Fabre, Emmanuel Chaput & Michel Diaz

**Learning to learn by doing by doing**
Suzanne J. Suprise & Richard G. Feifer

**Full Paper-Award Student Hon.**

**Support for Cooperation in Smalltalk**
Kenn Hussey, Ivan Tomek

**Use of WWW resources by an intelligent tutoring system**
Roger Nkambou & Gilles Gauthier

**Full Paper**

**Infusion of Telecommunications Technology into a Project-based Curriculum: Running with the River**
Natalie M. Abell, William D. Newsted

**Some effects of motivational elements in mathematical drill-and-practice software**
Andrea Abercrombie & John King

**A WWW Microworld for Mathematics**
Kostadin Antchev, Markku Luhtalahti, Jari Multisilta, Seppo Pohjolainen, Kari Suomela

**DIALECT: Digital Interactive Lectures in Higher Education**
Nicolas Apostolopoulos, Albert Geukes, Stefan Zimmermann

**Intelligent agents to support the effective collaboration in a CSCL environment**
Gerardo Ayala & Yoneo Yano

**Tools and services for authoring on the fly**
Ch. Bacher & Th. Ottmann

**What's IS all about?: A multimedia aid for learning information systems (IS) concepts and methodologies**
Seung Ik Baek, Jay Liebowitz & Alisa Leibowitz

**Interface design to support active learning**
Philip Barker

**Evaluating educational multimedia programmes in North America**
Antonio R. Bartolome & Lauran Sandals

**MURIEL: a European Multimedia Interactive Training System for Librarians**
Margaret Barwick
Learning as action: A social science approach to the evaluation of interactive media
Peter Baumgartner & Sabine Payr

User navigation strategies for multimedia tutorials
Barbara Beccue & Joaquin Vila

How I can't teach without making noise
Alfred Benney

Multiple Levels of Use of the Web as a Learning Tool
Evelijn S. Bos, Annemieke Kikstra, Christina M. Morgan

An Interactive Cooperative Teleworking Environment
C. Bouras, D. Fotakis, V. Kapoulas, S. Kontogiannis, K. Kyriakou, P. Lampsas, P. Spirakis, A. Tatakis

The Harlem Environmental Access Project: A Partnership with Columbia University, The Environmental Defense Fund, and the Public Schools of Harlem, New York
Joseph Bowman, Jr.

The Development of a Computer-Mediated Academic Communication System
Duane T. Brandau, Xuming Chi

Breaking the spell: Towards a reconciliation of education and television
Brian Burke

A multimedia training tool for speech impaired clients
D.J. Calder, B.M. Chen & G. Mann

Hypermedia interface design and mental models: A case study
Licia Calvi

HCID: An Experience in Collaborative Work and Distance Education
Daniel Campos D., Pedro Salcedo L., Pedro Rossel F.

The experimental learning cycle as a framework for integrating multimedia case studies and task workbenches
T.T. Carey & M. Blurton-Jones

A formal approach to the EMI model and case study
Enrique Espinosa Carrillo, Marc Boumedine Montaner & Ivonne Chirono Barcelo

Multiplatform implementations of the EMI model using the JAVA technology
Enrique Espinosa Carrillo & Alejandro Brito Lopez

"Getting Lost in Hyperspace": Lessons learned and future directions
Carlo Castelli, Luigi Colazzo & Andrea Molinari

Experiences in evaluating electronic books: Hyper-book and Ceasar
Nadia Catenazzi, Ignacio Aedo, Paloma Diaz & Lorenzo Sommaruga

Efficient methodology for automatic video-content indexing and retrieval of lectures for CAI systems
S.L. Chan & Horace H.S. Ip
A computer logging method for collecting user-reported inputs during formative evaluation of computer network-assisted distance learning
Chien Chou

Evaluation of a hypermedia music CAL system
Huey-Wen Chou

Lauren Cifuentes, Teri Metcalf, Gwendolyn Webb-Johnson, Karen L. Murphy, Trina Davis

The effect of technology on student learning
Vicki L. Cohen

The 'Learning Station': An Interactive Learning Environment for Distance Learners in Geographical Information Systems.
Sarah Cornelius, Ian Heywood

Teacher-learners cooperation produces an innovative computer-based course
Giorgio Da Bormida, Giuliano Donzellini & Domenico Ponta

Superhighways for Teachers AND Teachers for Superhighways (Invited Speaker)
Niki Davis

ScienceSpace: Research on using virtual reality to enhance science education
Chris Dede, Marilyn C. Salzman & R. Bowen Loftin

SLIM: A model for automatic tutoring of language skills
Rodolfo Delmonte, Andrea Cacco, Luisella Romeo, Monica Dan, Max Mangilli-Climpson, Francesco Stiffoni

Multimedia: How INTER-How ACTIVE: Do we really know? Concern about 'positions' and priorities for action
Jim Devine

A Teaching and Learning Framework for the Images for Teaching Education Project
Patrick Dillon, Alison Hudson, Penni Tearle

Simulations: New "worlds" for learning?
Carolyn Dowling

When is software both valuable and viable?
Stephen C. Ehrmann

Learning styles and hypermedia courseware usage: Is there a connection?
Ainslie E. Ellis

Networking in Fifth Grade: Learning Through Exchanging Questions and Answers
Michele Evard

Hypercalculus: Will students be completely satisfied with our Hypertext, one day?
Laura Farinetti & Anna Rosa Scarafiotti

Remote Tutoring: What we Learned by a Practical Experience
Laura Farinetti, Giovanni Malnati
Multimedia communications: Designing for interactivity
Richard G. Feifer & Denise Tazbaz

Designing effective multimedia programs to enhance teacher problem solving skills and cognitive flexibility
Gail E. Fitzgerald, Brenda Wilson & Louis P. Semrau

The evaluation of a distributed multimedia foreign language learning system
Sandra P. Foubister, Patrick McAndrew & Terry Mayes

Networks, Workstations, Multimedia, and Electronic Communities: Creating a University Learning Environment
Wendy A. L. Fowler, Richard H. Fowler

A framework for CAL performance support: An open hypertext model
Jane M. Fritz

Foundations for the Learning Web
Brian R. Gaines, Douglas H. Norrie & Mildred L.G. Shaw

Visualized conceptual structuring for heterogeneous knowledge acquisition
Tatjana Gavrilova & Alexander Voinov

Interactive multimedia information: Evaluation by home users
Mark Gillham & Kathy Buckner

Obstacles in Web Multimedia Publishing: Bringing Conference Proceedings On-line
Peter A. Gloor, Fillia Makedon, Oliver Van Ligten

Networked, asynchronous student evaluations of courses and teaching: An architecture and field studies
John Greenwood & Mimi M. Recker

QTVR aided urban design and planning
Shen Guoqiang

Computers and the College Classroom: Two studies of Computer Training and Use Patterns
Marjorie L. Hatch, Mary Sue Hayward

Embedding game's attractiveness into CALL system
Toshihiro Hayashi, Yukuo Hayashida & Yoneo Yano

Qualitative diagnosis of error-based simulation for error-visualization
Tomoya Horiguchi, Tsukasa Hirashima, Akihiro Kashihara & Jun'ichi Toyoda

Encouraging the investigation and solution of real-life problems with Mathematica and QBasic
R. Ilango & Tock Keng Lim

Broadband architectures for arts education: An exploratory study
Susan Jacobson

Understanding Teaching in the Video Conferencing Classroom
Peter Jamieson & Elaine Martin
MASK: Multimedia Audit Situated Knowledge
Rodger Jamieson & Andrew Chodkiewicz

Multimedia-based case studies in education
Ewald M. Jarz, Gerhard A. Kainz & Gerhard Walpoth

A classroom-based multimedia teaching system: SHARE
Zhang Ji-Ping & Italo De Diana

Scriptable Applications: Implementing Open Architectures In Learning Technology
Jeremy Roschelle, Rich DeLaura, James Kaput

Learning computer skills in school
Satu-Sisko Koivula & Eero Ropo

Software factories for active learning environments
Michael Korcuska

MediaADE: The MHEG-based distribution multimedia/hypermedia Application Development Environment
Sei-Hoon Lee & Chang-Jong Wang

Flexible link architectures in hypermedia systems
Jennifer Lennon & Hermann Maurer

Adaptive Interaction through WWW
Fuyau Lin, Ron Danielson, Sherry Herrgott

ATM as a Facilitator for Distance Learning
Marilyn Kemper Littman

Supporting Learning from Field Experience in Teacher Education
James M. Laffey, Dale Musser

Net-Frog: Analyzing monthly user access patterns on the WWW
Valerie A. Larsen, Mable B. Kinzie, Steven M. Boker & Joseph B. Burch

Obstacles to the Implementation of Computer-Assisted Reporting Courses
Kevin C. Lee

Comparative Analysis of Teacher’s Discourse and Students’ Behaviour in Traditional and Distance Lectures
Benoît LEMAIRE, Pascal MARQUET, Jacques BAILLÉ

Collaborative learning with multimedia
Min Liu

Engaging high school students in multimedia development
Min Liu & Keith Rutledge

A computer-based tutor for teaching and learning word problem-solving
Chee-Kit Looi & Boon Tee Tan
Formal language as a medium for technical education
Edward S. Lowry

Specifying educational software: Goals and process
Christophe Marquesuzaa, Jaques Meyranx & Thierry Nodenot

Is this thing really going to work?: The development of two computer-based multimedia programs
Mary Mauldin, Robbin Cullum, Diane Raeke, G. Robert Ross

Courseware market: Problems and solutions
Hermann Maurer & Nick Scherbakov

HM-Card: A new approach to courseware production
Vanessa Mayrhofer, Nick Scherbakov & Keith Andrews

Creating A Multimedia Interface To Teach Inexperienced Circuit Board Assembly Line Operators How To Correctly Assemble Circuit Boards.
Fergal McCaffery & Michael McTear

A flexible multimedia tutoring system for medicine
James J. McGregor, John Poyser, Margaret E. Anderson & Ali A.H. Mansour

A practitioner validated list of competencies needed for courseware authoring
Sara McNeil

Multimedia and language learning: A study of features that support off-screen communication practice
Carla Meskill & Mingming Jang

A software tool for educational research in pictorial communication
Ch. Metaxaki-Kossionides, S. Vazouras & S. Sehperides

The effect of on-screen instructor gender and expressivity upon adult learning of basic skills from a videotaped lesson
Arnold Meyrow

Virtual Knowledge Park: A Cooperative Learning Environment in Cyberspace
David Mioduser, Avigail Oren, Amichay Oren

Cal-farm: A Distance Learning CAL Project for Farm Investment Decision Makers
Ian Moncrieff, Des Thornton, Larry Nelson, Mike Jefferson

The Technology Rich Classroom Project: Where Learning Soars
Mike Muir & JoLynne Crout

An interactive hypermedia tutorial for power electronics instruction
A. Moreno-Munoz, J. Ortiz-Medina & A. Plaza-Alonso

The design and evolution of an authoring environment and its applications
Tomasz Muldner, Kasia Muldner & Christine Marie van Veen

Authoring a literary hypermedia encyclopedia CD-ROM using hypermedia modeling technique
Fabio Nemetz, Jose Valdeni de Lima & Altair Cardoso Borges
Linking Models to Data: Hypermodels for Science Education
Eric K. Neumann

Implementing a Student Allele Database via the World Wide Web
Lee A. Newberg, John A. Kruper, David Micklos

School work: Learning and leading in an information age
Joy Nunn & Ron Toomey

FAST: A research paradigm for educational performance support systems
Jennifer J. Ockerman, Lawrence J. Najjar, J. Christopher Thompson, Christopher J. Treanor, & F.D. Skip Atkinson

Knowledge awareness: Bridging between shared knowledge and collaboration
Hiroaki Ogata, Kenji Matsuura & Yoneo Yano

The Western Australian Telecentres Network: Enhancing Equity and Access to Education in Rural Communities
Ron Oliver, Gay Short

Hypermedia and the transfer of self-directed learning
C. Paakkanen & J.J. Viteli

Distributed computing network for science and math education in rural New Mexico
Andrea P.T. Palounek, Connie L. Witt, M. Carolyn Briles, Jeff Dulaney & Norman Georgina

Developing the Virtual Campus Environment
G. Paquette, C. Ricciardi-Rigault, C. Paquin, S. Liegeois and E. Bleicher

Authoring an interactive multimedia CD-ROM on French civilization
Rebecca M. Pauly

Telematics for Education: the Design of a Distributed Computer-Based Collaborative Learning System.
Domenico Ponta, Anna Marina Scapolla, Mauro Taini

Implementation Aspects of Information Technology at a Campus University
C.L.M. Pouw, J.T. van der Veen, A.B.M. Koppen

International Collaboration Using Digital Media
Patrick Purcell, Gerard Parr

Distance Learning System for Telekom Slovenije
Matev Pustišek, Janez Bešter, Peter Homan

Strategy for Setting up a Multimedia Resource Centre for Hungarian Universities
Peter Rackso

How to measure the behavioural and cognitive complexity of learning processes in man-machine systems
Matthias Rauterberg & Roger Aeppli

Design and Operational Assistance of a Pedagogical Virtual Space
Claude Ricciardi-Rigault, France Henri and Lise Damphousse
Revising an environmental information database using interactive multimedia technology
H. J. Rosen

First Amendment Rights and the Internet in K-12 Schools: Legal Precedent from Print Media
Russell I. Rothstein

Presenting HyTime documents with HTML
Lloyd Rutledge

Education via hyperobjects on the Web
Carola Salis, Francesco Benevento & Andrea O. Leone

New tools of the trade: Using multimedia in the history classroom
Steven Schoenherr

World-Wide Intelligent Textbooks
Elmar Schwarz, Peter Brusilovsky, and Gerhard Weber

A computer based student Welfare Information Support and Help system
Peter J. Scott, Janet Curson, Geraldine Shipton & John McAuley

The Role of Electronic Communication in Supporting Beginning Teachers
Michelle Selinger

Incorporating Asynchronous Collaborative Learning into an AS Engineering Degree Program for Home-Based Learners: Challenges, Strategies and Tools
John Sener

SWAN: A student-controllable data structure visualization system
Clifford A. Shaffer, Lenwood S. Heath & Jeffrey M. Nielsen; Jun Yang

Creating Educational Guided Paths over the World-Wide Web
Frank M. Shipman III, Catherine C. Marshall, Richard Furuta, Donald A. Brenner, Hao-wei Hsieh, and Vijay Kumar

Analysis of hypermedia browsing processes in order to reduce disorientation
Ana Paula Sousa & Paulo Dias

Assessing the Learning of Distant Students: Competency-Based Instruction
Emilie D. Steele, Frank Linton

An experimental comparison of effects of dynamic and static visual displays in computer based instruction on declarative and profnd
Michael Szabo & Ron Schlender

Change in the use of alternate delivery systems through professional development within colleges and universities
Michael Szabo

HyperMed: A hypermedia system for anatomical education
The effects of different computer-based instructional modes on students of different cognitive styles
Seong-Chong Toh

A learning-lab where AI meets hypermedia
Guglielmo Trentin & Vittorio Midoro

The metaphoric hammer: Driving messages home through the use of metaphor in an EPSS
Rick Trevail & Robert Chafetz

Assessing the usability and effectiveness of a remote language teaching system
Anna Watson & Angela Sasse

Educational hypermedia systems for the Earth Sciences: Students as authors
Denise A. Wiltshire & Carmelo F. Ferrigno

Analyzing the Process of Learning in a Web Based Community of Learners
Karsten D. Wolf

A multimedia authoring system for building intelligent learning systems
Wing-Kwong Wong, Tak-Wai Chan, Yao-Sheng Cheng & Shih-Shen Peng

Concept-map based navigation in educational hypermedia: A case study
Romain Zeiliger, T. Reggers & Robert Peeters

Cooperation in a hypertext environment
Zizi Zhang

Panel

Ways of Knowing Teaching with New Technologies
Deborah Ball

From straightjackets and blinders to infinite space: Using the Internet to transform writing in the classroom
Robert M. Bender, Glenda Moum & Byron T. Scott

Educational applications of virtual reality
Jack A. Chambers, John Q. Mullins, Veronica S. Pantelidis, Eben Gay & Carl E. Loeffler

Finding Common Language and Common Ground: The Talking Mathematics Videotapes
Rebecca Corwin

Technology planning for connecting kids
Mary Flynn-Maguire, Cheryl Zupan & Jill Moffitt Cullen

General and specific issues in applying standards in multimedia development
Lynette Gillis, Peter S. Ho & Martin R. Ramirez

Video Analysis in an On-Line Professional Community
Margaret Honey
Multiple Perspectives on Using Multimedia To Provide a Common "Text" for the Study of Innovative Teaching  
Magdalene Lampert

School-Based Lesson Study Groups: Exploring American Practice through Japanese Teaching  
Jim Stigler

Collaborative inter-class teaching and research over the Internet: Students’ perspectives on the research and learning process  
Thomas Treadwell, Adel Barimani, Hanna Kellar, Michelle Pole & Erin Ross

Roundtable

E-mail metrics: It is better to give than to receive  
Gerald Knezek & Rhonda Christensen

Making the most of learning opportunities: The role of reflection for action, on action, and in action  
Som Naidu, Ray McAleese & Jacques Le Cavalier

Applications of interactive technologies for reluctant readers  
Raymond S. Pastore, Stefanie Pastore & Paul Quick

Redesigning Courses for the Computer  
Carol Washburn, Prabha Vasudevan

Short Paper

Development of an Electronic Teaching and Learning System for Undergraduate Degree Courses  
Marco Adria

Multimedia Training in the Mining Industry - Collaborative Development in Customised Projects  
Trish Andrews

The EduAnet Project: Education Across Internet  
Walther Antonioli, Michel Rudoy

An interactive, simulated experiment for biochemistry and molecular biology students  
Mark Arundel & David Day

The relationship between linear/nonlinear navigation and linear/nonlinear mental models of hypermedia environments  
David J. Ayersman, John M. Oughton & W. Michael Reed

Content based retrieval in an educational video system  
Antoni Bibiloni, Ricardo Galli & Bartomeau Estrany
Towards the Definition of a General Model for the Transfer of Knowledge in Multimedia-Based Learning Systems
Marc Boumedine Montaner, Ivonne Chirino Barceló and Enrique Espinosa Carrillo

The Development of a Computer-Based Academic Tracking System with PowerBook and PowerTalk
Duane T. Brandau, Xuming Chi

Using virtual reality technology for learning design skills
Ted Carpenter-Smith & Lisa Seaman Anderson

Large-Scale, Hypermedia-based, Course Legacy Systems
MAJ Curtis A. Carver Jr.

An intelligent multimedia tutoring system for quality control training in the food industry
Oscar Castillo & Patricia Melin

A Learning Activity Development System on World Wide Web
Chih-Kai Chang and Gwo-Dong Chen

A script-based development environment for instructional games
Gwo-Dong Chen & Chih-Kai Chang

Assembling the Double Helix: Development of an NCTM-compliant interactive mathematics learning environment
S.C. Andrew Chen, George L. Johnston & Kai C. Liu

Global Classrooms In Perspective: Reflecting On Five Years Of The Air/Water Projects
Rhonda Christensen, Gerald Knezek

Facing east: Multimedia interface design for the Far East
Jiin-Tian Chyou & Norman Eisley

A multimedia computer-based test generation system
Donald H. Cooley & Jianping Zhang

Creating Engaging Courseware Using System Dynamics
J. Michael Spector, Pål I. Davidsen

The University of Colima Distance Education Project
J. Eliezer de los Santos & S. Lourdes Cruz

FRAMES - A User-Controlled Practice Environment in Theoretical Computer Science
Ruth de Villiers

The Role of the Multimedia Features in the Natural World on the HumaKnowledging Processes. Application to the Design of Computer Mediated Communications
Sophie M. DELOUIS

A Model of Architecture for Integrated Open and Collaborative Hypermedia
Paloma Díaz and Ignacio Aedo

Planning and development of an interactive computerised assessment system
R.C.A. Donnelly, M.D. Mulvenna & J.G. Hughes
Designing Hypertext: What we can learn from Linguistics and Discourse Research
Mary Ann Eiler

Fixing Chinglish!: Developing educational multimedia for Asian ES\textit{L}\textit{a}\textit{r}\textit{n}ing
Norman Eisley & Jiin-Tian Chyou

Authoring semantic hypermedia: A concept mapping approach
G.J. Elliott, Eleri Jones & P. Barker

Embedding the aesthetic objective in educational multimedia design: Adding the human element
Veronica I. Ent

The language of art
Sandra Ewing & Robert Munro

The Evaluation of Electronically Delivered Distance Education Courses
Stuart Fletcher and Robyn Benson

Developing multimedia courseware: Two EFL applications for teaching phonetics
Richard Foley

Eleven lessons from the DARGS '93 hypermedia conference proceedings
James Ford, Fillia Makedon, Charles Owen & Samuel A. Rebelsky, Kenneth E. Harker, P. Takis Metaxas

A different learning approach: The hypertextual paradigm
A. Franich

Reflections on the multimedia explanation
Giovanni Fulantelli, Mario Allegra & Alessandra Salerno

Institutional faculty development in education technologies to improve classroom teaching: Launching the IDO Pioneers and Guides
Michael Randy Gabel & Veronica D. Feeg

Implementing the Learning Web
Brian R. Gaines & Mildred L.G. Shaw

The Underserved Families Internet Research Project: A Case Study
Michael Gallo, Melinda Bier

Recording and Replaying of an X-Session: an Approach for an Asynchronous Interaction Method
Lassaâd Gannoun, Philippe Dubois, Jacques Labetoulle

Visual programming in Smalltalk
Randy Giffen & Ivan Tomek

Letting Learners Be Learners: Combining Constructivism and Computer-based Instruction
Doug Holyoak, Ken Goldwasser

Partners in cognition: Problem-based learning with computers
Ian Hart
Learning with hypermedia: What users do and how to observe it automatically
Joachim P. Hasebrook & Gilbert Fezzardi

An authoring metaphor to match constructivist theory
John Hedberg, Barry Harper, Robert Wright & Grant Farr

Shifting the paradigm as schools and technology improve
Kathleen Heide, Mary Beal, Tom Cook, Susan Lynds & Michael Nicholson

An Interactive Distributed Distance Education Environment
Jwu-Hwa Ho, Wen-Han Lin, Jia-Sheng Heh and Tzong-Tsann Wu

Using the World-Wide-Web to Promote Faculty Development in the Use of Technology
Michael R. Hoadley, Jeri L. Engelking

A study of cognitive effectiveness on computer-assisted learning
Jon-Chao Hong, Jing-Shin Yang & Ming-Chou Liu

Integrating the Internet into the Undergraduate Curriculum
M. Eleanor Irwin, Janice Crichton Patterson

A hypermedia-driven computer assisted mathematics remediation package: From prototype to problem shell with tracking mechanism
Jeff James & Margaret Taplin

Implementation of new technologies in Hong Kong Polytechnic University
John Jones & Jeff James

The Multimedia Mentor
Frank Kaduk, Richard G. Feifer

Courseware authoring method for ITS on WWW
Y. Koike, M. Maruyama, K. Nakabayashi, Y. Fukuhara & Y. Nakamura

Evidence-based advising
Michael Korcuska, Joe Herman & Menachem Jona

Simulation in the learning of automated systems
Jean-Baptiste La Palme

Computer-Mediated Discussion in a Postgraduate Course: Some Observations
Kwok-Wing Lai

Interactive Distance Learning Network Decision Model
Joyce M. Lang

Teaching hypermedia use more effectively using mental models
Richard F. Lewis & Michael J. Lewis

The customer-focused evaluation of the LEAP intelligent tutor
Frank Linton

Navigation through medical digital video libraries
S. Suave Lobodzinski, Leonard E. Ginzton & Hermann Maurer
Assessing Educational Multimedia Courseware
A.D. Marshall and S. Hurley

An Approach to Implementing Adaptive Hypermedia for an Intelligent Tutoring System on the World-Wide Web
Mina Maruyama, Kiyoshi Nakabayashi, Yoshimasa Koike, Yoshimi Fukuhara and Yukihiro Nakamura

The work expansion and implementation of multimedia authoring tool "Tsumiki": Generating webpage, visual editor and OLE support
Tsutomu Matsumoto, Hideo Kiyohara, Hidenori Miyamoto, Chieko Kouyama, Hideki Hayashi, Keiji Uemura & Shinsuke Shiota

A comparison of the influence of CD-ROM interactive storybooks and traditional print storybooks on reading comprehension and attitude
Kathryn I. Matthew

Keeping Up With The Jones's: A Survey Of New Technology on The World Wide Web and Their Instructional Potential
Thomas Fox McManus

A virtual hand with tactile feedback for virtual learning environments
T.A. Mikropoulos & E. Nikolou

Mediated Design: A Collaborative Learning Experience
Karen Madsen Myers, Lorraine Sherry

Effects of navigation structure in CD-ROM courseware on learning achievement
Som Naidu & Jenny L. Wilson

Building a demonstration multimedia electronic performance support system
Lawrence J. Najjar, Jennifer J. Ockerman, J. Christopher Thompson & Christopher J. Treanor

Promoting structural knowledge by computer based case studies: Studies on different help systems
Helmut M. Niegemann

Teaching social skills through face-to-face versus computerized instruction
Beverly B. Palmer, Robert Dutile & Sharla Solsma

AGD: Knowledge modeling in an instructional design support system
Gilbert Paquette, Francoise Crevier, Claire Aubin & Eric Bleicher

Hypermedia in the literature classroom: Literalizing poststructuralism
Christiane Paul

Learning Environments for Manufacturing: a Framework and Example
Valery A. Petrushin and Chris Thompson

An interactive environment based on a distributed architecture for an educative museum application
Gilbert Pinot, Gerard Metzger & Bernard Thirion
Dimensions of learning styles and their influence on performance in hypermedia lessons
Karen Rasmussen & Gayle V. Davidson

A systems approach to adaptive computerized instructional design: The relevance of guiding principles
Roger D. Ray

Why and how to teach hypermedia in introductory computer science courses (summary)
Samuel Rebelsky

A review of the research on the effect of learning styles on hypermedia-related performance and attitudes
W. Michael Reed

Collaborative Educational Design towards Collaborative Learning
Franz Reichl

Hypermedia learning environment for especially mathematically gifted students for mathematical word problem-solving
Heli Ruokamo-Saari

Hyperstories for creative thinking
Jaime Sanchez & Mauricio Lumbreras

Evaluating structural organization of a hypermedia learning environment using GOMS model analysis
Terry Shikano, Mimi Recker & Ashwin Ram

Using World-Wide Web (WWW) Technology for Teaching
Zafar ul Islam Singhera

MultiWorlds-II: Multimedia microworlds instrumentation tools
Peter Skobelev, L. Berdnikov, S. Garchev, S. Kazarine, I. Maiorov, V. Rasskazov & A. Sverkounov

The effects of an interactive learning environment on learning styles
Keng-Soon Soo & Yeok-Hwa Ngeow

Creating engaging courseware using system dynamics
J. Michael Spector & Pal I. Davidsen

CBL Evaluation: The Why’s, What’s & How’s
G. Stubbs & M. Watkins

Design and Development of the CORAL System
Chuen-Tsai Sun

Exploring the role of video in learning from hypermedia
Karen Swan, Carla Meskill, Bill Reilly

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Enhancing Student Learning by Incorporating Learning Styles into Adaptive Hypermedia

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Abstract: This paper outlines a project to enhance student learning using course hypermedia and an adaptive hypermedia system based on student learning styles. Initial attempts at generating networked hypermedia at the United States Military Academy produced a wide variety of tools which students could use to prepare for lessons. Students had on-line access to over one gigabyte of hypermedia course information including lesson slideshows, note-taking guides, lesson objectives, extensive course hypertext, a student response system, a configurable virtual computer, and extensive graphics, sound files, animations and digital movies. This plethora of tools confused some students as they were uncomfortable making active choices of what course material would be most conducive to their learning. Furthermore, an assessment of the multimedia and hypertext documents in the course revealed that the value of a particular multimedia tool to a student varied widely. Each student was traversing the course material according to their own unique learning style. As a result, an adaptive hypermedia interface was developed that tailored the presentation of course material based on the individual student's learning styles. Adaptive hypermedia, implemented through Common Gateway Interface forms and based on the Felder learning style model, provided this mechanism. Every time a student logs into the course hypermedia, the interface into the course is dynamically generated based on the student's learning style. By tailoring the presentation of material to the student's learning style, the authors believe the students learn more efficiently and effectively.

Introduction

The Problem

To address this problem, a series of hypertext, multimedia and hypermedia tools were developed as the basis for enhancing the course, CS383, Computer Systems [Carver & Biehler 1994a, Carver & Gregory 1995a, Carver et al. 1995a]. These tools provided a rich selection of World Wide Web (WWW), hypermedia-based tools as depicted [Fig. 1 and 2] and described below in [The Course]. These enhancements to the course were enthusiastically received by students and significantly improved the performance of many students. This enhanced student control and flexibility over how and when they studied and transformed many students from passive to active participants in the education process. Unfortunately, it also confused some students as they

[1] The views expressed in this paper in no way express the official position of the United States Military Academy, the US Army or the Department of Defense. All insights are the authors' own.
were unsure as to how to proceed through the plethora of course material. Anecdotal evidence based student surveys over 1 ½ years suggests approximately 25% of the students remained confused and uncertain at the end of the semester as to how to effectively use the hypermedia material [Carver & Howard 1995a]. This wasted student time and required a different approach to presenting course material to students.

While providing a single path through the material was considered, this was inconsistent with the goal of transferring control and flexibility to the student. What was needed was a mechanism for tailoring the presentation of the course material to different students based on how they learned best. By tailoring lesson presentation to the individual student, students should learn more in less time because the students can absorb the material presented more rapidly and are more receptive to how the material is presented. As a result, an adaptive hypermedia approach using student learning styles was developed.

Previous Efforts

Adaptive hypermedia interfaces have been discussed in several papers [Beumont & Brusilovsky 1995a, Boyle & Encarnacion 1994a, Brusilovsky & Pesin 1994a, Beumont 1994a, Brusilovsky 1992a, Fisher et al. 1990a, Hekmatpour 1995a]. These papers have focused on dynamically assembling information and presenting that information according to the user's class and knowledge state. No attempt was made to incorporate the student's learning style into the decision of what information to present to the student. Likewise, Felder's learning styles have been presented in several papers as the basis for conducting classes [Felder & Silverman 1988a, Felder & Baker-Ward 1990a, Felder 1993a] but have not been adapted for implementation into hypermedia-based courseware. In only one instance has Felder's Learning Styles been incorporated into multimedia courseware [Montgomery 1995a]. This multimedia courseware is more than two orders of magnitude smaller than the CS383 Computer Systems hypermedia courseware. No system coupling Felder's learning styles with adaptive hypermedia to provide tailored lesson presentations has been proposed or implemented. In this regard, this paper is both novel and significantly different from previous efforts in this field.
The Course

The course utilizing this approach is CS383, Computer Systems, which is typically offered to third year undergraduate students. This course covers in detail hardware technologies in personal computers as well as providing a brief introduction to several areas in computer science such as computer networks, the Internet, robotics, artificial intelligence, expert systems, human factors, automated decision-aiding tools, computer graphics and office automation. The class size is less than eighteen students per section.

The hypermedia course material consisted of: A ISMAP-based HTML interface to course materials [see Fig. 1]; lesson objectives; Harvard Graphics for Windows or PowerPoint slideshows with sound, graphics, executables, and digital video embedded in the slides for every class [see Fig. 2]; a note-taking guide; a course hypertext document over 300 pages in length with 178 cross references, 678 glossary terms, and 700 searchable index terms; 184 sound files, 147 graphics, 57 digital movies, and 13 links to other external programs that support the course material; a course legacy system consisting of over 250 student presentations and papers from past semesters; an animated virtual computer [see Fig 2]; and a student response system [see Fig. 2]. The animated virtual computer allows students to build a virtual computer, run a series of benchmarks against the computer, and consists of over 40 HTML files, 25 digital movies, and five animated benchmarks. The student response system is an adaptive testing system with over 250 questions tied to specific lesson objectives and levels of Bloom’s Taxonomy. These questions include true/false, multiple choice, short answer, fill-in-the-blank, and essay questions. Students could, at any time before, during, or after class utilize these hypermedia lessons. The intent was to transfer control over how and when the students learned to the students. No longer were the students locked into fifty-five minutes of interaction with the instructor three times a week. Instead, the students had complete access to all of the lesson materials available twenty-four hours a day.

Felder’s Learning Styles

According to [Felder & Silverman 1988b], there are five dimensions of learning that define a student's learning style of which four are measurable: sensing/intuitive, visual/verbal, active/reflective, and sequential/global. Professors likewise present material according to their learning style which is often quite different from the students they are teaching. Instructors tend to present material in an intuitive/auditory/inductive/reflective/sequential manner while their students are predominantly sensing/visual/deductive/active/sequential learners [Felder & Baker-Ward 1990a]. In only a single dimension does the presentation of material match the learning styles of the presentation’s audience. Adaptive hypermedia addresses this shortcoming by providing tailored, networked, hypermedia course material to the students according to their individual learning styles.

Adaptive Hypermedia Based on Learning Styles

Common Gateway Interface (CGI) forms are used during the first lesson to determine each student’s learning profile. These forms are based on an assessment tool developed at North Carolina State University [Solomon,
Students determine their learning style by answering a series of twenty-eight questions [see Fig. 3]. Based on the student's responses, the CGI executable calculates each student's individual learning style, stores this student profile as a file on the WWW server, and associates it with the user's login. There are 720 different, possible learning styles that could be generated from the initial survey.

When the student logs in to begin a lesson, the student is given the option of exploring the course material according to their learning style or without their learning style. If the student chooses to use his or her learning style, a second CGI executable loads the student profile and calculates the effectiveness of the different course media using the heuristics described below. Based on these calculations, the CGI executable dynamically creates an HTML page containing an ordered list of the lesson media elements [see Fig. 3]. These lesson media elements are presented to each student in a sorted list ranked from most to least conducive based on their effectiveness to each student's individual learning style. The students need only to sequentially click on the links to explore the course material according to their personal learning style.

Relating Learning Styles to Course Hypermedia Materials

Key to this approach is a determination of what types of media types are appropriate for different learning styles. Each hypermedia course element supports one or more learning characteristic. However, regardless of which hypermedia lesson component is chosen, all components support both active and reflective learners. Instead of passively accepting the information presented, the hypermedia course forces students to constantly make choices. This facilitates active learners who become actively involved in the learning process. Reflective learners are likewise facilitated by the computer-based nature of the material. Students can stop and reflect at any point during their studies and ponder the meaning of the material presented. As a result, these learning characteristics are removed from consideration in the adaptive hypermedia interface leaving the sensing/intuitive, visual/verbal, and sequential/global learning characteristics as the basis for the adaptive hypermedia.

Certain media is inherently appropriate to different learning styles. For example, slideshows, graphics, and digital movies clearly appeal to visual learners while the course hypertext with its text-based, hierarchical, presentation of material appeals to verbal, sequential learners. For other media types, media content will determine the degree of support for each learning style. Each course tool was rated on a scale from 0 to 100 to determine the amount of support for each learning style. This rating was combined with the student profile to produce a unique ranking of each media type from the perspective of the student's unique profile. This ranking will differ from course to course depending on the course and media content. Different courses, media, and instructors will result in different tool ratings.

Adaptive Hypermedia Tool Granularity

In ranking the course media, the granularity of media ranking can significantly impact on the overall effectiveness of the hypermedia interface. If each media element (cpu.gif, intro.wav) can be assigned a learning style ranking, then the adaptive hypermedia system has fine granularity. If each media type (sound files, graphics, hypertext, etc.) receives a ranking, then the adaptive hypermedia system has coarse media granularity. There is tradeoff between the accuracy of the adaptive hypermedia interface and the speed of development of the hypermedia courseware. Adaptive hypermedia systems with fine media granularity accurately match the student's learning styles with the specific media that most directly supports that learning style. However, each media element must be rated in terms of its support of different learning styles. Adaptive hypermedia systems with coarse media granularity can be developed more quickly but are not as accurate.

In determining which approach to pursue, there are two key factors: the size of the resultant hypermedia courseware and the homogeneous nature of the media elements. As the size of the hypermedia system grows, the cost of providing fine tool granularity also grows. In the case of CS383, Computer Systems, the size of the courseware was felt to be too large for a fine granularity adaptive hypermedia interface. Additionally, if the media elements within a media type are homogeneous (i.e. all of the sound files are voice-overs used for the same specific purpose), then little accuracy is gained using a fine granularity adaptive interface. CS383 has fairly homogeneous media elements within the different media types and as such, the coarse granularity model provides the better interface.
Future Research and Summary

Future research is based on extending the current working model of the adaptive hypermedia system to (1) allow the student the option of overriding the ordering of media and instead provide their own ordering and (2) provide fine media granularity. A comparison between two sample populations using fine and coarse media granularity will validate the perceived tradeoff between cost of development and the accuracy of the adaptive hypermedia interface with relationship to the student's learning style. Additionally, the relationship between various media tools and learning styles is unproven in a formal study. Additional research is required to validate the validity of this relationship in CS383. The validity of the relationship will always depend in large part on the content of the various media elements.

Adaptive hypermedia based on student learning styles provides the ability to individually tailor the presentation of course material to each student. The underlying idea of adaptive hypermedia based on learning styles is quite simple: adapt the presentation of course material so that it is most conducive to each student learning the course material. To a certain extent, each student is taking a different course based on what material is most effective for each student. This tailoring allows for efficient and effective student learning in the shortest possible period of time. Student reaction to the adaptive hypermedia system has been uniformly positive. The adaptive hypermedia system for determining learning styles is public domain software and is available through the primary author.

Endnotes

Off-Campus Preservice Teacher Education via IMM Technology:  
An Indigenous Cohort Case Study

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Abstract: Since 1990 the School of Education at James Cook University, Australia, has produced and delivered on- and off-campus teacher education courseware materials via interactive multimedia (IMM) mode. Over a similar time period a research program has developed to investigate, primarily, the effectiveness of IMM courseware, especially in terms of its mathemagenic properties. This paper documents pertinent research conducted with a cohort of Indigenous off-campus teacher education students studying through IMM materials in their remote home communities. The findings led to a profile of the cohort's (a) study approaches; (b) perceptions and usage patterns of IMM materials; (c) thinking process while interacting with the IMM courseware; (d) concept mapping and IMM courseware, (e) thinking and use of IMM click-drag interactions, and (f) usage patterns and perceptions of embedded metacognitive activities in the IMM courseware.

Setting the Context

Racial discrimination, minimal sustainable political power, educational marginalisation, land alienation and, for some, geographical remoteness place indigenous minorities, such as Australia’s Aboriginal and Torres Strait Islander peoples, in the centre of the equity and social justice debate. Part of the solution is the Remote Area Teacher Education Program (RATEP) that is an affirmative action initiative driven by the concepts of social justice, culturally appropriate education, empowerment, and interactive multimedia information technology. The program is designed to deliver preservice teacher education to Aboriginal and Torres Strait Islander students in their own communities. The course is taught by the same lecturers who teach it on campus, the difference being that the subjects are delivered via interactive multimedia computer (IMM) courseware, other electronic technology (facsimile, audioconferencing, and electronic mail), print material, and on-site tutors.

In association with the traditional on-campus model, much research has focussed on student teachers' learning styles but virtually none with respect to Indigenous students who are studying in their own cultural milieu. This paper address this paucity by presenting data from a series of ecologically-valid research studies to describe Indigenous students' study approaches, IMM material usage patterns, and thinking processes in an attempt to develop a profile of their learning attributes whilst studying for a Diploma of Teaching (a university qualification for teacher registration) via the RATEP mode.

The cohort referred to in this paper comprised 23 students (6 males and 17 females) studying across six RATEP study centre sites (York Island, Boigu Island, Bamaga, Hopevale, Cairns, and Cherbourg). All students have English as their second or third language and were adult learners who were considerably older than the usual preservice on-campus teacher education students, with only one having benefit of a Year 12 high school education. Students were selected to undertake the course on the basis of having completed a para-professional teacher education qualification, personal commitment, and motivation to becoming a registered teacher. Undertaking academic learning at university level was an entirely new experience for all but two students who, nevertheless, left the on-campus course after approximately one year's study.

Although the cohort consisted of 23 students, the number of students in the various research studies reported in this paper varies. By way of an overview, the studies are as follows:
1. Ascertaining students' study approaches. A study of the 23 students was undertaken using the Study Process Questionnaire (SPQ) [Biggs 1987] to assess students in terms of surface, deep, or achieving approaches to learning.
2. Usage patterns of IMM courseware materials. Data reported in this paper were obtained from three separate studies of 19 students’ usage as they studied three different, one semester IMM subjects in the RATEP program.
3. Student thinking. Three studies form the database for the information detailed in this paper: (a) click-and-drag cognitive mapping with 10 students, (b) IMM and concept mapping with 21 students, and (c) IMM and metacognitive interactions with nine students.

Approaches to learning

How students undertake formal study is very much related to their study approaches. According to [Biggs & Moore 1993], study approaches can be viewed from two perspectives: (a) the presage notion of orientation or predisposition to learn in a certain way and (b) from a process notion of how ongoing tasks are handled. The approaches to learning refer to consistent ways that students undertake their learning or study and derive from a student's metacognition, linking both motives and strategies for study with perceived task demands and desired types of learning outcomes. Based on [Marton's 1975] original conceptualisation about approaches to learning, [Biggs & Moore 1993] have postulated three types: surface, deep, and achieving. The surface approach is characterised by extrinsic motives whereby the student engages in tasks and passes minimally in order to gain a paper qualification. A deep approach is characterised by intrinsic motivation and strategies that are meaning-oriented. Achieving approaches occur when motives and strategies are associated with institutionally desirable learning outcomes, namely high grades.

To ascertain student study approaches, [Biggs 1987] developed the SPQ which provides profiles on students with respect to surface, deep, and achieving motives and strategies. In the SPQ manual, six of the more common profiles encountered in a quantitative study of on-campus university preservice teacher education students are: deep, achieving, deep-achieving, surface-achieving, surface, and low achieving. As part of the overall description of the cohort of Indigenous students reported in this paper, the SPQ was administered to gain information about their study approaches. The questionnaire was administered in a way that attempted to overcome obstacles associated with cross-cultural context and English as a Second-Third language. In some items the on-campus examples were inappropriate for the RATEP model so wording was sometimes reinterpreted to place it in the RATEP context: for example, one question referred to "lectures and labs"; this was changed to "teleconferences and IMM courseware session".

Analysis of the RATEP cohort's results showed that, as a group, the students displayed strong evidence of metalearning skills. That is, SPQ results indicated high ratings for students' awareness of and control over motives or intentions for study and strategies in line with such intentions. By way of contrast, [Biggs 1987] stresses that students who lack metalearning capability choose strategies that are incongruent with motives. In addition, results reveal that, as a group, the RATEP cohort does not align with the six profiles listed above. The current students tended to be reflective and "thinking" learners who were flexible in identifying motives.

IMM Research Studies

IMM Courseware Materials: Student Perceptions and Usage Patterns

Three studies conducted over a period of three years have been completed in this area. Two investigated usage patterns of RATEP students as they interacted with two 13-week subjects: Contemporary Australian Society (CAS) (19 students) and Primary School Mathematics Education (18 students) [Henderson & Putt 1993; Putt, Stillman & Henderson 1995]. The third study involved learner navigation access patterns of another 13-week IMM subject, Australian Minorities Today in World Perspective (18 students) [Henderson & Arger 1995]. The students were totally immersed in IMM courseware as a mode of studying. In the first two studies, data were collected by a survey instrument comprising structured and open-ended questions and interviews while in the third study, observation, modified stimulated-recall interviews [Marland, Patching & Putt 1992], and culturally appropriate yarning-type interviews were conducted. In this paper general findings are reported based on the three individual studies. The findings tended to be consistent across the three studies. In general, the following points can be made about student usage of materials.

1. All but two of the students preferred to work alone when studying with the IMM courseware for the first time.
2. In the maths subject most students preferred to revise their work individually whereas with the other two subjects the majority emphasised the strengths of collaborating with others on the first or second revision.
3. They preferred to work cooperatively only after everyone had acquired some information because they considered it a waste of time interacting with someone who had as little understanding as themselves.
4. The majority of students worked through the screens systematically and sequentially.
5. When confronted with information they did not understand, students backtracked to revise previous screens.
6. A few also revised the whole unit (even if they backtracked to clarify information as they went through) in order to put everything into context once more.
7. The majority of students considered the number of interactions (questions-answers-feedback) in the maths subject just about right but wanted more in CAS.
8. None of the students wanted the correct answer presented to them following their first incorrect response in interactions. They see this as a lack of faith by lecturers in the students’ intellectual abilities. They were adamant: “I want to do my own thinking”.
9. On the second incorrect answer, many students revised in order to more thoroughly understand the work before returning to attempt the question once more. They repeated this sequence until their answer was correct. They “won’t let the computer beat me”.

Student Thinking

Click-drag Interactions

This study investigated the cognitive processes employed by 10 RATEP students as they completed a set of click-drag interactions as part of an IMM package specifically developed for the purposes of this research but whose content was founded on an IMM subject previously completed by the students (Henderson & Patching, 1995). To enable a focus on student cognitive processes, the study employed a hybrid paradigm of process-tracing research developed by [Marland et al. 1992] which involved a modified stimulated recall methodology to gain data on students’ cognitive processes. This involved interviewing students as they interacted with the computer IMM courseware. Interviews were taped and transcribed for analysis.

The IMM material was designed to engage the students for approximately 30 minutes, and the requirement for the interaction was to place represented examples of cultural change into appropriate conceptual categories. As in the original subject, the items (concepts) to be grouped were chosen for their possible multiple construal of meaning. This element of ambiguity was introduced to facilitate thinking. The findings of this research were as follows:
1. Two broad categories of cognitions that relate to student action in completing click-drag interactions were identified, namely proactive and reactive.
2. Student reporting of the proactive thinking reflects cognitions that occur before the placement of items in the appropriate conceptual category. Two types of proactive thought were indicated: (a) student thinking that related the current information to rule-bound data, namely course material by the way of previous examples or definitions and (b) thinking that related the information to self-generated conceptualisations which allowed them to elaborate in terms of justification, exemplification and deducing. The difference between these two pathways is that one is trying to fit the information to a prescribed definition or example while the other is trying to rationalise it in terms of the entire conceptualisation of categories based on student constructed schema.
3. Reactive cognitions were characterised by trial and error strategies whereby guessing appeared to be the modus operandi. In such instances action could be either purely for expediency, that is, non-considered placement of the items purely to allow progression onto the next stages of the IMM material, or for feedback which results in reflection by students. Trial and error action can then stimulate thinking processes. As a result, such action is reactive. This is substantially different from hypothesis or theory testing which inherently requires proactive thinking.
4. Transcript analysis resulted in a total of 33 cognitive processes being reported by students.
5. The majority (24) of actions taken by the students were categorised as considered; that is, they involved proactive thinking.
6. There were seven instances of reflective thinking as a reaction to trial and error action. Several of these instances were characterised by purposeful thinking patterns.
7. Two cognitive processes were related to guessing for expediency so that students could "skip over" the set click and drag activity and continue with the rest of the program.

The findings from this study suggest that click and drag interactions stimulate a range of important cognitive processes in students.

Concept Maps

In a study of the efficacy of IMM in teaching and learning concept mapping [Henderson, Patching & Putt 1994a], 21 RATEP students were asked to construct on paper their own map on the concept of culture. This was required after interacting with the IMM stimulus material which was a modified segment from Australian Minorities Today in World Perspective which they had completed studying two months previously. It comprised two examples of
concept maps. Firstly, the sequential build-up on screen of a concept map for cultural change involved the progressive differentiation of subordinate concepts and examples linked by unlabelled uni-directional relational arcs; and secondly, the students completed a click-and-drag concept map interaction on the same concept.

The students' concept maps were examined to address two questions: (a) how effective was IMM as an instructional medium for teaching and learning concept mapping. The concept maps were examined to see to what extent the concept maps were informed by the actual IMM subject completed previously, the immediate IMM stimulus screens, or the students' own everyday prior experiences; and (b) what was the quality of student thinking. This was ascertained by analysing the relative complexities of the concept maps, specifically by looking at hierarchical progressive differentiation of lexical nodes and directionality, labelling, and integrative reconciliation of the relational arcs.

1. The variety of ways of using concept mapping as components of the IMM instructional package do in fact bring about students' learning of concept map construction as approximately 80% of the students showed strong evidence of being informed by the IMM subject or stimulus screens.

2. There is strong evidence to suggest that as a result of the IMM instructional package students were able to conceptualise at progressive differentiating levels and, then, exemplify where appropriate. Ten students produced lexical nodes to four subordinate levels while seven went beyond four levels. In the first three levels, most students produced concepts for their lexical nodes while at the lower subordinate levels, four through eight, students tended to provide examples of concepts. This is an important finding when viewed in the light of [McDonald's 1989] findings which found that Aboriginal and Torres Strait Islanders tend to focus on the example rather than the conceptual level.

3. The student-generated concept maps were not replicas of those modelled in the IMM courseware and stimulus materials. For instance, over half (53%) were able to go beyond the IMM concept mapping models to include simple (e.g., is, are, of) and/or complex (e.g., phrases, clauses, transitive verbs) labelling of the relational arcs. They also provided directionality to those labelled arcs thus making clear the students' conceptualisation.

4. The majority of the concept maps showed inter or cross level linkages (653 instances) but there were only 29 instances of intra-level or cross branch linkages provided by five of the 21 students. The IMM concept mapping courseware did not model these sorts of cross branch linkages that may explain why some students did not demonstrate a meaningful understanding of the horizontal relationship between groups of concepts.

IMM and metacognitive interactions

RATEP students' perceptions about the worthwhileness and transferability of metacognitive activities that occurred as a result of purposeful instructional design were investigated in a study by [Henderson, Patching & Putt 1994b]. Two design techniques were employed: (a) metacognitive interactive strategies of the question-answer-feedback format that were unavoidable as the students had to type in an answer before the IMM program would allow them to proceed, and (b) metacognitive prompts that were included in the discourse in the IMM subject but that students could elect to action mentally or ignore, that is, they were not required to type in an answer. The actual design required students to think about such things as: the image or thoughts that concepts brought to their mind; what the topic heading suggested the subsequent information might be concerned with; questions they might ask themselves about their level of understanding and what actions they would take; their thinking when they compared answers or ideas, critiqued content and theories, and worked out their answer to questions; and their thoughts while identifying the topic sentence and main ideas.

Nine students were surveyed using a structured questionnaire that focussed on eliciting information with respect to both metacognitive interactions and prompts. Questions attempted to elicit data for the following: (a) the evolution of their feelings, attitudes and motivation towards doing the metacognitive interactions and prompts, (b) whether students answered the interactions and prompts properly, that is, whether they engaged in metacognitive activity to produce a thoughtful considered answer, (c) whether there was transfer to dissimilar situations. The main findings of this study were as follows:

1. Initially the general reaction to the metacognitive interactions was negative. Students reported feeling confused, hesitant, frustrated and lacking in confidence. Their later positive reactions to interactions confirmed growing confidence in their ability to metacognise as well as realisation of the value of metacognition, even in cross-cultural situations.

2. All students reported positive predispositions towards metacognitive prompts, probably because students could avoid them or elect not to do them properly. One student summarised a common attitude: "I don't have to type anything...sometimes I thought I was cheating myself for not taking the time properly to respond sensibly."
3. Two students typed considered answers all of the time, four most of the time and three some of the time to the metacognitive interactions. The reasons given were to do with seeking, analysing, and evaluating their understanding.

4. The seven who did not do the interactions properly all the time explained that they were unsure of their own thinking particularly in relation to the concepts being explored, and that their first language confounded their thinking in an English as a second-third language situation with academic genres.

5. The pattern of initial reaction of metacognitive prompts was similar to that for interactions (in 1 above).

6. Six students said they did the metacognitive interactions properly all or most of the time during revision. Their explanation is tied to their ways of studying with IMM courseware, as outlined above in the section, Student Perception and Usage Patterns. These students overviewed the whole topic and, when they felt they had a grasp of the concepts, the theoretical argument, and what was required of them, they revised in a manner that employed more metacognitive strategies.

7. Two students reported doing the metacognitive prompts properly during revision all the time, one reported most of the time, five students said they did them some of the time, and one, never.

8. Analysis revealed that the students were using metacognitive strategies in deciding when they believed redoing metacognitive prompts was necessary. For example, one student said: "If I am on a new topic...I sometimes revised back to the previous...metacognitive prompts to get my understanding right and flowing again". A few believed that, on referring to their notes, the "first attempt was usually correct".

9. Seven of the nine students reported positive transfer benefits of learning metacognitive strategies for other subjects. One student put this succinctly: "Had I not been introduced into that method [metacognitive interactions] it would have been very hard for me to understand what is being taught in the subjects. I have been able to work on other subjects and make meaning of them".

10. Eight recorded transfer to writing essays. "I became a confident writer. I knew what I needed to write and planned accordingly. My essay writing became clearer and more meaningful", was one student's response.

11. Some students commented on the positive effects of transfer to other aspects of the total RATEP course and professional activities: "...Aboriginal and Torres Strait Islander people take things for granted and we more or less or never ask questions or seek reasons on why things happen. So, getting us to reason with things is certainly a step in the right direction for our intellectual and social growth".

**Conclusion**

The profile of this Indigenous student cohort which is emerging from these studies has the following characteristics. The SPQ results indicate that they possess metalearning skills that were demonstrated in an awareness of their motives for study and control over their study strategies. Evidence of these metalearning skills was found in the studies that related to usage patterns of IMM courseware, cognitive processes when completing click and drag IMM interactions, the efficacy of IMM for learning concept mapping, and perceptions about the worthwhileness and transferability of metacognitive activities. The findings suggest that IMM can be instructionally designed to capitalise on students' study strategies to promote metalearning skills that students perceived they actually applied in dissimilar situations.

The SPQ results also revealed that, as a group, the RATEP cohort did not align with the six profiles from the SPQ. Future research needs to investigate the relationship of the students' cultural contexts to their study profiles as indicated by the SPQ.

**Reference List**


Efficacy of Story in Multimedia Training

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Abstract: This paper investigates the value of story in computer-based adult education. Story elements including genre, conflict, and character were used to create the basic structure of a 32-hour multimedia self-study business processes course. The educational impact of story was considered in terms of memory for content, learner motivation, and cultural context. An analysis framework was developed to categorize the survey and structured interview data. Learners were able to construct detailed memory of the course content. Additionally, learners reported high levels of interest in the course and were able to formulate course outcomes that followed story flow. Learners perceived various cultural qualities of the story and often compared their experience of the course to personal experiences. Refinement of the analysis framework and assessment of long-term impact of story are suggested.

Introduction

One of the primary goals of Andersen Consulting Education is to create powerful learning experiences for the more than 30,000 employees of Andersen Consulting worldwide. This is accomplished in the classroom with goal-based scenarios rich in human interaction and problem solving. Andersen's multimedia products are based on simulations and goal-based scenarios as well. In pursuit of a more powerful multimedia experience, Andersen Consulting Education is using story as an instructional strategy. With this strategy, elements of story structure are used to create an interactive experience that increases learner motivation and retention, as well as the fidelity of the learner’s experience. This paper describes one application of this strategy in a multimedia training course, Business Processes Overview (BPO); a methodology for studying its effects on learning and motivation, and some preliminary results.

It may seem intuitive that stories help people learn. Certainly people have been using stories to communicate their experiences since prehistoric times. From cave drawings to mythology to oral tradition, story has been used to pass along human experience and knowledge. At some point in history however, the disciplines of entertainment and education went their separate ways, each developing techniques and methods for achieving their own goals. Yet the goals are not completely separate. Sincere entertainers attempt to communicate important themes and messages, to change their audience in some way. Educators also work to create experiences which change their audience in some important way. They struggle with motivation and maintaining the learner’s interest in the experience. Sometimes they succeed in engaging their audience; other times the training is an experience to be endured, not to be enjoyed. Clearly there is common ground between these disciplines that can be used to create a more effective learning experience.

The modern learning sciences already embrace story in some way. Today’s more sophisticated training uses goal-based scenarios and case studies. How does story make it different? What distinguishes a story from a case study? The difference is the intentional use of certain key elements of classic story structure - action, character, conflict, and genre. These are the tools that the entertainment industry uses to capture and hold the attention of audiences. By using these elements to structure a case study, the content is transformed into a story which should engage the learner and motivate them to continue the experience.

Definition of Story
We define story as the interaction of action, character, conflict, and genre which creates a pattern of tension and release that the audience finds enjoyable. Action is the basic material of a story - the events that occur. Character is the complement to action in that characters participate in the action of a story. Conflict is the challenge the characters must overcome -- the spark which drives the entire action of a story through the classic dramatic structure -- inciting incident, rising action, climax, and denouement. This structure creates a pattern of tension and relaxation, surprise and insight which is interesting and enjoyable for the audience. A genre is an established story pattern such as the western, the action/adventure, or the mystery story. A genre describes archetypal conflicts, characters and action common across many stories. The audience uses the genre of a story to set their expectations and interpret the action during the course of the story.

Cognitive Theory and Story

It may be obvious that stories can be used to motivate and teach. It is far from obvious why one should study the psychology of story and learning. The fact is, if story is to be used as a legitimate instructional strategy, it must be understood in the same terms as other strategies such as analogy, graded problem sets, simulation, etc. While people have used stories for ages to communicate and to teach, we have only recently begun to appreciate why stories work the way they do. There are several lines of research which converge on the use of story in education. Together they describe the potential effects of story in terms of memory structure, motivation, and a concept we call “content bandwidth.”

Memory Structure

Stories help us structure our memories. It is natural for us to remember a good story and the meaning it communicates. According to Roger Schank, this is because stories are natural units of storage and retrieval in human memory. We store new experiences in the form of stories and generalized scripts (Schank, 1990; Schank & Abelson, 1977). Scripts are memory structures which define the essential elements or actions in an experience, and help create expectations for what will happen next and what may be done. A person’s "restaurant" script will help him or her understand a new restaurant experience and create expectations as well as a set of acceptable actions. Stories are specific experiences remembered, while scripts are the synthesized product of many experiences. Thus, people may have dozens of restaurant stories and one main restaurant script.

People also classify their experiences into one or more genres. Just as genre creates a set of general expectations for a fictional experience, real-life genres set expectations for real experiences. All computer-based training experiences have certain common elements - alone with a computer, some kind of grading system. Consulting engagements tend to follow a common pattern as well. Knowing these genres provides a person with a familiar base of expectations in which the new and unique can be experienced.

One key objective of the Business Processes Overview course is for students to learn a new script - how to analyze a business in terms of its processes. By using a specific story as a context for performing the analysis, we expect students to remember the new script in greater detail than if they learned it out of context. By placing the story within a familiar genre, an Andersen Consulting engagement, we set the students’ expectations for an established structure which maps to their prior experience. This use of genre should help the students structure the new elements of the story and content within their existing base of experience.

Motivation

For a learning task to be meaningful, the learner must have sufficient context and motivation to perform the task (Savery & Duffy, 1995). Stories provide context and motivation for a task in the following ways: creating a specific situation where the learner’s action is required and will have some consequences; offering the learner a appropriate level of challenge while minimizing the threat of the task; and creating for the audience empathy with the protagonist and a curiosity to find out what happens next. This last characteristic, the ability to generate interest in what happens next, is probably the most pervasive. In self-study training, maintaining interest is a constant challenge. By using a storyline of progressing conflict throughout the course, we expect students to maintain a high level of interest during the 32-hour course.
Content Bandwidth

Stories have been used for ages to communicate content on many different levels. Zen philosophy is taught using koans, or paradoxical stories. Judeo-Christian culture has been passed along largely through stories. A story can simultaneously provide a context for the learning task, teach deeper cultural messages, give an emotional impression, and ultimately help tie learning to personal experience. Indeed, the best stories operate on several different levels, providing a broader "bandwidth" of content communication.

Another objective of the Business Processes Overview course was to communicate the culture of a typical functionally-oriented products company. By embedding this content in the storyline and characters of the course, we expect the learners to remember specific cultural aspects of the case company and relate them to their own experience.

Story Structure in Business Processes Overview

The Business Processes Overview Course is an interactive story / simulation designed to teach consultants how to analyze a client's business processes, using Andersen's resources and methodology. Learning outcomes include analysis skills, knowledge about the targeted industry, and knowledge about Andersen's process resources. The target audience is consultants with 18-36 months experience. Expected student contact time with the course is 32 hours.

The course is structured around six scenarios which occur at a single client engagement, Synchro Electronics. The scenarios include learning tasks of increasing complexity and take place in different parts of the company (engineering, sales and marketing, purchasing and manufacturing, etc.) The six scenarios are connected by a single storyline which progresses as the scenarios are completed and culminates in a dramatic conclusion with three possible endings.

The story uses a combination of two genres: the "computer-based training application" and the "Andersen Consulting engagement" story. The first genre sets the expectations for the overall structure and purpose of the experience. The second helps set a richer context for the learning task, and a pattern for the types of conflict, action, and characters the learner will encounter in the experience.

In our "Andersen Consulting engagement" story, the conflict focuses on whether or not the client company (personified by the CEO) will survive its current situation of sagging financial performance. As the story progresses, the conflict escalates as an aggressive board member offers to buy out the company and relieve the CEO of his management responsibilities. This progression of conflict builds throughout the course, so each new learning task is set up with a new element of the story and a new level of conflict. This conflict motivates the learner to perform the tasks necessary to help the CEO.

The characters in the BPO story are derived from the two genres, CBT and AC engagement. Thus, there is a coach/manager who gives assignments and evaluates the student's work. The coach/manager works for an Andersen partner, who interacts with the CEO of the client company. The CEO is the protagonist of the story, facing the main conflict embodied in the hostile board member. Other employees and two financial analysts round out the cast to create a believable and interesting case company which communicates the proper content messages. Professional actors were used to realistically portray the characters in the course.

A Methodology for Determining the Educational Value of Story

The three aspects of story described above were the focus of our evaluation methodology. Our methods included a questionnaire and a structured interview. The design of each question was driven by our predictions about how story impacts learners. A group of twenty four consultants completed the course. Each of these participated in the structured interview following course completion. Seventeen of the learners had the opportunity to answer the questionnaire items. Some items were presented only once while others were presented after each of the five course modules. Thus the range of questionnaire responses varied between seventeen and eighty-five.
We coded the responses using the framework in Table 1. The three rows represent the type of content in the responses, ranging from content only, integrated content and story, and story only. The columns represent the degree of detail ranging from general to specific to personal experience.

<table>
<thead>
<tr>
<th>General</th>
<th>Specific</th>
<th>Personal Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Only</td>
<td>1.1 Mention of content at a conceptual level - no use of business process terminology</td>
<td>1.2 Mention specific recommendations/issues or use of specific business process terminology</td>
</tr>
<tr>
<td>Content and Story</td>
<td>2.1 Mention of content at conceptual level with reference to the engagement genre</td>
<td>2.2 Integration of both business process content details and story details</td>
</tr>
<tr>
<td>Story Only</td>
<td>3.1 Comments about engagement genre only</td>
<td>3.2 Details of the story without mention of business process content</td>
</tr>
</tbody>
</table>

Table 1. Response Analysis Framework

Memory Structure

Two components of memory structure were considered in our analysis. First, the BPO course used a client engagement genre which should have given the learner a familiar context in which to structure new experiences. To assess the effect of genre, the learners were asked directly and indirectly to rate the familiarity of the simulated client engagement environment.

On a scale of 1 to 5 (1= not at all and 5= very much so), was this activity realistic compared to problems arising on an actual engagement?

The average rating was 3.93 based on the fifty eight completed samples collected after each course module by the twenty four learners. This finding confirms that the client engagement genre was communicated clearly in the course.

Learners were also asked to compare their experience in the course with other experiences. On a scale of 1 to 5 (1= Not at all and 5 Very similar), how similar was this course compared to:

- Printed self-study experiences
- A videogame
- Classroom experiences
- A novel
- Other computer-based training
- Real project experiences
- Time with an industry expert
- A novel

Learners consistently rated this experience to be most like real project work (mean = 3.86) which is consistent with the predicted effects of the client engagement genre. “Other computer based training” was ranked second most similar to the BPO course (mean 3.42) which also follows the original stated design assumptions. The experience was also rated to be highly similar to time with an industry expert (mean = 3.28). The course was rated least like printed self-study experiences (mean = 2.35) or a classroom experiences (mean = 2.50).

Second, to assess the memorability of the business process content learned in the course we asked questions using cues for recall that varied in story detail. For example, the question: "What did you do when Synchro's LMM-MAX laptop experienced serious quality problems?" was asked to trigger detailed recall of the newly acquired script for process analysis. The question " What did you learn about how to help a company solve its quality problems?" was asked to see if less-detailed recall of the content would result. The free form responses were coded according to the content and level of detail. (Table 1.) Their answer types are presented following each question.

a. What specific things did you do to help Synchro solve their quality problem with the LLM MAX?
b. What did you learn about how to help a company solve its quality problems?
Over 80% of the story-cued responses (a) were coded as 2.2, integrating details of both story and content. The general-cued responses (b) were evenly split between cells 1.1 and 1.2, showing less detailed recall of content. This result suggests that the both story and content details were encoded together in memory and that the story was an effective cue for recall of detailed content. One learner, when given the general question, talked for a while at the general content level (1.1), but continued .. “I’m trying to remember some of the aspects of the exercises and what are the major problems we’ve all recognized....It’s very difficult to go back unless you can put it in some sort of context. I’m trying to remember the events of Quality [the name of the module in question] (pause)” The student then proceeded to generate a more detailed and integrated response (2.2). This suggests that the story served as an effective structure for storage and retrieval of content.

What was the most memorable or interesting thing about Synchro?
40% of the responses were coded as 2.2, integrating details of both story and content. Another 20% of the responses were coded 2.3, relating story and content details to personal experience. The remaining responses were spread out evenly across the other cells. This result is consistent with the other memory responses in that both story and content details were recalled together. The 20% which related the story and content to their experience indicate successful use of genre, as well as integrated learning of new content.

Taken together, the above results show that story in Business Processes Overview helped structure learners’ memory of the course content to facilitate detailed recall and integration with personal experience. Our data reveal that both the genre and story details are encoded by learners. We believe this result is important since genre represent a learning vehicle not typically exploited in computer-based education. When a learner experiences any form of training, he or she primarily perceives the “training” genre and formulates expectations about the experience (e.g., “I can fail without significant risk,” or “This is not work”). Our data suggest that story can introduce additional genres to which learners are sensitive and enable them to form expectations for learning. The finding that this course was most similar to a real client engagement is evidence that the engagement genre was able to influence learner expectations and provide strong context for learning new business analysis behaviors.

Learner Motivation

In our research, we considered several aspects of motivation as part of the story experience. First, to assess the impact of story on learner motivation, we recorded subjective reports of interest after each module of the course. Second, we assessed the extent to which story had created expectations in the learner for what would happen next.

Please indicate how interested you are in the issues raised in this course (1 = not interested, 10 = very interested. The average rating of 8.93 directly supports the hypothesis that the story sustained high learner interest.

Considering what you have learned up to this point about Synchro, what do you think will happen next?
Each response was coded according to the criteria presented in Table 1. Over 70% of the responses fell in the detailed categories (1.2, 2.2, 3.2). That learners were able to make predictions with supporting rationale provides evidence of their interest and attention for the sequence of activities and events.

The motivation results confirm that the story helped the learners maintain interest in the course over a sustained period of time. One learner revealed her excitement about the story in these words:

"The changes we are making to Synchro are pretty sweeping. I mean we are changing a lot of the things they are doing and for the purpose of the training I think it is necessary because you can concentrate on one area.... I think the storyline is very feasible and actually I'm very curious to know what happens in the end!"

These and similar comments suggest that learners were truly engaged in the plight of Synchro and were motivated to see the story to its end.

Content Bandwidth
We embedded the culture of a typical products company with characters and typical inter-departmental dynamics to convey the culture of a functionally oriented company. To assess how well these messages were learned, we asked the following questions:

What cultural messages did you perceive either about Synchro or about Andersen from the course? 65% of the responses were coded as 1.2, containing both content and story details. Another 29% were coded as 1.3, relating details to personal experience. This indicates that the cultural messages embedded in the story were recalled in detail by most learners, with some readily relating the messages to their own experience.

When you think about Synchro, do any of the personalities who work there come to mind? All of the respondents recalled at least one character from the story. Half of the respondents were able to recall two or more characters.

The story proved to be an effective strategy for conveying the intended cultural messages helping learners relate the content to their experience.

Overall Impact of Story

We completed our assessment of the efficacy of story by simply asking learners what value, if any, they found in the story components of the course. All learners responded that the story was valuable in some way. 75% of the responses mentioned “maintaining interest” as valued; 67% of the responses mentioned content messages as valued, and 25% of the responses related the overall story to their personal experience.

Conclusion

While it may be obvious that story is a desireable instructional strategy, it is important to understand the effects of story in the same terms we understand other strategies. The Business Processes Overview course is an attempt at systematically using tools from the discipline of entertainment -- action, character, conflict, and genre -- to enhance the learning experience. This study of the Business Processes Overview course and its effects on learners shows that story can add value to the learning experience in terms of motivation and memory for content at both detailed and general levels. Our story was intentionally grounded in both the course content and the learner’s experience with a familiar genre. The intentional manipulation of genre in an educational context represents a robust vehicle to facilitate learning new behavior. Overall, story created a learning experience that integrated motivation, detailed content, and cultural content messages.

We have also introduced a framework for evaluating the effects of story on memory, outlining a progression from general content recall to detailed integration of story and content to integration with personal experience. Future research will focus on refining this framework and applying it to longitudinal studies of memory to assess the long-term effects of story on learning.

References


Experiences with Learning Scenarios in an Authoring Support Environment

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Abstract: We report on experiences with a software-engineering technique, scenario-based design, in a prototype authoring support environment. Scenario-based design has been shown to provide an effective method to explore, refine and communicate user-centered designs for interactive software systems. We demonstrate that these benefits can be achieved for the design of interactive learning environments, in which scenario-based tools can draw on both user-centered design approaches and the variety of educational theories available to support the design of instructional software.

Scenario-Based Design as an Authoring Support Tool

For designers of interactive software, a usage scenario is a narrative description of what people do and what they experience as they try to make use of computer systems. Scenarios are employed to capture interesting features of a current situation, or to help designers envision and communicate new ways to work. The defining property of a usage scenario is that "it projects a concrete description of activity that the user engages in when performing a specific task, a description sufficiently detailed so that design implications can be inferred and reasoned about" [Carroll 1995].

Scenarios force designers to consider the range of users who will use the system and the range of activities for which they will use it. Scenarios are populated with fictional but possible characters, who want to undertake real work. During the detailed design, the scenarios can be revisited with comments such as 'OK, but what would Hillary do?' or 'Deepak won't like that arrangement'. [Preece et al 1994]

In scenario-based design, usage scenarios are developed early in the design process and employed to drive later stages. This makes it easier to discuss use and to design use. Development of scenarios supports the following processes in interactive system design [Erickson 1995]:

• defining the problem: the design team learns about the problems users will face
• team building: the team develops a shared understanding of their project and of the skills of each member
• collaborative design: the team explores design alternatives and their consequences
• user involvement: scenarios help users comprehend the design
• design evangelism: the design project must be communicated to sponsors
• design transfer: the rationale of the design must be communicated to those who will implement or reuse its components.

Usage scenarios complement system prototypes as vehicles for exploring, refining and communicating interaction designs. Without some such record of design intent, prototypes by themselves may hide design assumptions, provide little linkage from design decisions to results of usage analysis, and highlight surface decisions about interface features rather than the more difficult questions about how people use the system to achieve their goals [Atwood et al 1995].

Our work takes place within a project to develop an authoring support environment for case-based learning systems. Current efforts on authoring support systems frequently focus on facilitating the reusability of instructional components [van Joolingen and de Jong 1995, Major 1995, Frair 1995]. From previous studies of
Learning Scenarios to Support Instructional Design and System Specification

Here is an excerpt from a learning scenario created by an instructor for a course in Rural Development:

"Bruce decides to skim through the case study, having heard the Russian lecture and seen the video. He wants to see the video again so he skips the interview of Prof. Eidlin and goes to the Russian private farm video.

Bruce is having trouble understanding some words (e.g. Slavonic Feudalism, Decollectivization). He feels that these words are being used pedantically by the professor because he can't find them in the dictionary. So he turns his attention to looking at the slide images.

Again he comes across words or events (like Yeltsin's storming of the White House) which he doesn't understand. He then consults the glossary of terms accompanying the Russian module. With a clearer understanding of the words which were confusing him, Bruce relaxes and goes back to the interview with Prof. Eidlin."

Development of a Learning Scenario

Instructions to Authors: The authors receive the following definition as a preliminary guide to their creation of learning scenarios.

What is a learning scenario? We want the software being designed to reflect our thinking about how the learning will take place, rather than have the learning be a byproduct of the system design. So we specify first how we expect the learning to occur, then we or other members of the design team can fit the technology to this desired usage.

For that reason, we try to keep learning scenarios as free of a particular technology as possible. Even if you have some sample screens in the back of your mind, keep them there. Think about what the users will experience in terms of acquiring and processing information, and what the experience will feel like for them.

Learner Profiles: The first step in developing a learning scenario is the creation of a user profile. This makes the type of learner the author has in mind concrete. A concrete, personalized image of a representative learner is a critical feature in envisioning how the system will be used. Like the characters in a good novel, the learners in the scenario begin to take on a life of their own in the author's mind, and their reactions to the system can reveal to the author how actual usage will take place.

[Fig. 1] shows the user profile tool within the prototype authoring system [TRAILE] we are developing. The author enters the name, college, level, gender, learning styles and hobby for the student by filling in the blanks in
the dialog box. This information is pieced together by the system to create a profile for the student. The profile appears above the scenario so that the author keeps the student's character in mind while creating the scenario. The learning styles that are selected for the student will have an affect on the way the student approaches the learning tasks in the scenario. The learning styles are taken from several sources to avoid favoring any particular model of learning and to provide authors with a variety of styles to choose from. [Kagan 1960, Kolb 1984, Mann 1970].

Learning interactions

Fig. 2] shows the vocabulary suggestions for the individual actions contained in learning scenarios. The actions are adapted from [Gagne 1994, Merrill 1994, Silverman 1992]. As with the learning style elements in the user profiles, we have given authors a variety of sources and theoretical perspectives to draw on in constructing scenarios. The description has to be in sufficient detail that "The scenario identifies the user as having certain motivations toward the system, describes the actions taken and some reasons why these actions were taken, and characterizes the results in terms of the user's motivations and expectations" [Carroll 1995].

Further points about learning scenarios are illustrated by the following excerpts from the additional instructions given to authors in the TRAILE Guide:

Aren't these scenarios just stories? What's wrong with that? A lot of what we learn from each other comes in the form of "war stories". When you create a story about the learning experience, you provide an opportunity for other members of the design team to understand your thinking about how the learning should take place. You also may find that the story begins to teach you as well: good writers say that they create the characters and then the story often writes itself because they just record how those characters would respond to the events around them. We have found the same thing in using scenarios to help us design interactive computer systems - we greatly simplified the original TRAILE design after we wrote learning scenarios and found the characters [you!] in our usage scenarios were getting lost.

Any tips on writing scenarios? Keep them as concrete as you can, by focusing on particular instances of learning. Think of some of your typical or memorable students - we know, those aren't always the same people. Treat the scenario as a conversation with yourself: no fancy language, don't worry if it is
informal or open-ended. Remember you are describing how you envision things working for the learners, not specifying what they must do. Use your own judgment about exceptional cases: you can always create typical scenarios first and add interesting exceptions later.

Will anybody else read my scenarios? We won't put them in the exemplar library unless you OK it. But you will want to show them to the other members of your design team, so that they can understand your thinking. Your teaching assistants or other people who observe actual usage will know what incidents you will want to hear about because they tell a different story than you were expecting.

Figure 2 - TRAILE Learning Action Words

Integrating Scenarios into an Authoring Support Environment

We are experimenting with learning scenarios as part of the development of an authoring support system, TRAILE [Tools and Resources for Authoring Interactive Learning Environments]. Each of the proposed steps in the design process includes creation of a system component and a review by the author and other appropriate contributors:

- the Instructional Proposal specifies the audience, content and learning goals, instructional challenges or current learning difficulties, rationale for an interactive learning environment, development resources and estimated schedule. The Instructional Proposal is intended to be reviewed with a management team prior to commitment of resources.
- the Learning Scenario, as outlined above, is reviewed with other instructors and instructional designers.
- the Key Screen Mockup contains a potential screen design for each major activity area in the system. The Mockups are typically created by either an instructional designer or a learning technology systems developer.
the Walkthrough Demo extends the Key Screen Mockup with additional screens and processing logic to allow execution of a fixed script corresponding to a single learning scenario. The review uses a cooperative evaluation method with representative users to assess usability and acceptability. [Monk et al 1993]

the Working Prototype is a fully functional system to be deployed in the planned instructional setting for initial use and assessment. The Working Prototype has only limited media elements - video segments are rough cuts, audio files are recorded with non professionals, the Help system may be incomplete because initial usage will have support staff present as part of the assessment. The review employs actual usage data to compare against the Learning Scenarios and test data to assess how well the learning objectives have been achieved.

the Initial Release has complete media elements and is ready for exchange with other institutions. The exchange value or marketability of the software provides a final review of the system's success.

In each stage, the provision of exemplars and templates can support instructional design and system development. Linking sample screens and interaction patterns to learning scenarios and instructional goals ensures that reusable components can be viewed in the context of their purpose and rationale. The front-end components from the TRAILE system can be combined with other aids to enable courseware reuse [Siviter & Brown 1992].

Lessons from Learning Scenario Creation

The current TRAILE prototype has been used by several instructors creating interactive learning environments for university students and industrial users. We report in this section on their assessment of the benefits experienced from the process of scenario building. In each case the instructors were able to create one or more scenarios within a single hour of using the prototype, and all decided that the benefits they experienced justified development of more scenarios.

The benefits cited by instructors included:

• raising new instructional issues. One instructor commented that he had never given thought to how to address differing learning styles - "I see now that I should be considering how different students learn - now what do I do?" Another instructor, with a definite view about how his course should be structured and how material should be presented, realized that students might not experience the learning activities as he would have: "This is forcing me to think about things in a way that I hadn't thought about them before".

• revealing system complexity. One instructor found the character in his scenario getting confused by the complexity of his proposed design, and was able to simplify the interaction before a system prototype was constructed.

• envisioning new learning designs. One instructor initially constructed scenarios reflecting problems and misconceptions encountered by students in a previous version of the course. He went on to prepare new scenarios to flesh out a revised instructional design (9 scenarios in all).

• supporting communication with developers. For example, the developer of the Rural Development case study system used the learning scenarios created for it, such as the example introduced above, after a number of verbal explanations of the author's vision of the system. He found it a valuable introduction to the learning tasks and the content domain. He described the learning scenarios as "a basis for telling me what kind of searching the students will be doing and what their needs are".

We also asked one courseware developer, who had been working for two months producing ToolBook modules for a new course, to create learning scenarios without seeing the ones prepared by the author. As expected, she had difficulty creating learning scenarios herself because her view of the students was based only on what the instructor had informally told her in specifying the courseware system's contents. She commented that her implementation of the system would be more effective if she had a better idea of how the students approached the learning tasks.
Research Issues and Future Directions

In addition to the further development of later stages of the TRAILE authoring support environment, there are a number of features of scenario-based design which we have not yet captured in the TRAILE prototype. For example, we have not yet used the scenarios with learners, although early user feedback is frequently cited as a potential benefit of scenario development. In the TRAILE design process, user feedback does not come until the cooperative evaluation of the Walkthrough Demo. Since the content of the system is new to the intended users, it is difficult to envision ways to involve them before there is substantial content to work through.

A second issue to be investigated is the author's categorization of scenario actions according to a high-level classification of learning activities. For example, the "investigate and decide" type of goal based scenario instructional models contains five classes of learning activities: Problem introduction, Do, Decide, Communicate, and Wrap-Up [Bell and Kedar 1995]. When the learner controls the sequence of activities, it is valuable for the learning scenarios to describe typical sequences of activities. This would allow for data from testing to be used to validate and refine the author's understanding of learning sequences.

A final extension under consideration for TRAILE is the automatic capture of data about such high-level learning activities, and their presentation in an appropriate visualization. This follows the model of Expectation Agents which use design intent scenarios to monitor usage and detect potential anomalies [Atwood et al. 1995].

References


Abstract: This research examined hypertext study strategies for learning goals requiring factual learning, information application (problem solving), and information integration (interrelating text information). For factual learning goals, readers preferred selecting units for study from a topic list rather than a structural content map, and reviewed more than readers with information application goals. For information integration goals, readers preferred a content map for unit selection and took more notes than readers with the other two goals. They also reviewed more frequently than readers studying for information application, and were more likely to use self-testing questions than readers studying for factual learning. The different strategies resulted in differences in readers' depth of understanding for the text content. The findings indicate that readers are flexible in developing goal-specific strategies for studying hypertext, and that different text features support different types of hypertext processing.

Introduction

The ability to adjust text processing according to one's needs and objectives is central to skilled reading [see Kintsch, 1986]. Good readers focus attention on goal-related information and organize that content into knowledge structures appropriate to their learning goals. One advantage of instructional hypertexts over traditional textbooks is that appropriately designed hypertext could facilitate goal-specific text processing. Because readers can influence the order, content, and pace of their own learning material, they may be better able to focus on and organize goal-related information. Hypertext can also facilitate flexible text processing by providing study aids such as reader-generated notes and annotations, elaborative footnotes, and self-testing questions. In a hypertext, these can be easily accessed and are not constrained by space limitations. However, readers must be able to determine which study aids support the processing requirements of their learning goal, and how to use these aids effectively. Accordingly, the extent to which readers take advantage of hypertext's flexibility is likely to depend on the match between the readers' learning goals and the support for individualized text study provided by the hypertext [Dee-Lucas & Larkin, 1995; Wright & Lickorish, 1990]. The objective of this research was to examine how readers use a hypertext to achieve learning goals of varying complexity, and to assess what support features are most useful for these different goals.

The learning goals examined in this research required either factual learning (answering factual questions), information application (using text content to solve problems), or information integration (interrelating information from different portions of the text). Study strategies for these goals were characterized in terms of how readers used three features often found in instructional hypertexts: content maps and topic lists (used to display the content of text units), self-testing questions (for assessing text understanding), and note-taking. The number of units selected and unit review were also examined to assess differences in the amount of content read and how thoroughly it was studied. The effectiveness of the study strategies developed for the different learning goals was assessed by testing performance on the goals.

Method

Hypertext
The hypertext consisted of 17 content units (ranging from 1 to 3 screens in length) discussing the scientific measurement of length and time. Each screen had buttons for displaying a topic list (for selecting content units), a content map (also for selecting units), a screen for taking notes, a set of self-testing questions (subdivided into comprehension questions and application problems), and the learning goals (factual, information integration, or information application questions). There was also a button for returning to the previous screen. The button for displaying the learning goals (i.e., factual, information application, or information integration questions) allowed readers to review the assigned study goal at any time. The note-taking button displayed an area for recording cumulative notes.

Readers displayed units by clicking on their titles on either the content map or topic list. On the content map, unit titles were organized in a hierarchy indicating subordinate and superordinate relationships among units. Clicking on any of the titles on the map displayed the content of a text unit, with one exception. One title displayed a subordinate map with the titles of additional related units (i.e., subtopics of the unit on the main map). The topic list presented the titles of all units in alphabetical order, with no information about how they were related. The topic list did not contain links to any other lists (i.e., all titles were on the list).

The button for the self-testing problems displayed a screen with two buttons allowing readers to select a list of either comprehension questions or application problems. There were 17 comprehension questions, one for each unit. These questions tested understanding of the main idea of each unit. Readers could check their answers by clicking on a button which displayed the relevant text unit in a pop-up screen. There were 16 application problems. These required readers to apply the content from one or more units in solving a problem. An answer button displayed the answer to each problem.

Participants & Procedure

The participants were 60 undergraduates who had not taken any college level physics. Each reader was assigned to one of three learning-goal groups. The learning goals for the Fact group consisted of three questions requiring them to paraphrase text content. The Integration group was given two questions involving comparison and contrast of different portions of the text. The Application group had three problems requiring use of quantitative relations to solve problems or derive new relations. The learning goals for all groups dealt with the same text content.

All readers were told that they would be studying an electronic text in order to answer questions, and that they could see these questions at any time during text study. They also knew that they could take notes, and that they would be able to use the notes to answer the questions. They first used a practice hypertext to familiarize themselves with procedures for studying the text. They then studied the experimental hypertext with the assigned learning goals. After readers had finished studying the text, their notes were displayed on the screen and they answered the questions corresponding to their learning goal. Then all readers answered the questions for the other learning goals (which they had not seen before).

Results & Discussion

Study Strategies

The extent to which readers used the available hypertext features (i.e., content map vs. topic list, self-testing comprehension questions vs. application problems, and note-taking) was examined for each group. Differences in unit selection and review were also analyzed as indicators of the breadth and depth of text study.

Preference for Content Map vs. Topic List

Research on hypertext navigation facilities suggests that content maps or similar types of overviews help readers develop effective reading strategies, particularly when they lack specific study goals [Allinson & Hammond, 1989; Dee-Lucas & Larkin, 1995]. Readers may also find maps easier to use than more index-like access facilities [Monk, Walsh, & Dix, 1988]. However, the results of the current research indicate that readers' preference for a content map versus a topic list depends on the nature of their learning goal.

An analysis of the proportion of total unit selections made from the content map and topic list indicated that the Integration group used the content map significantly more than the Fact group [see Figure 1]. There was also a trend toward the Fact group using the topic list more than the Integration group (p<.06). There were no differences between the Application group and the other groups in use of the access facilities.
To further investigate preferences for unit selection, readers were classified according to the access facility they used most often. Readers who made 80% or more of their unit selections from either the content map or the topic list were classified as preferring that access facility. All other readers were classified as having no preference. A multiway frequency analysis on these data indicated that significantly more readers preferred the content map over the list for the integration goals, with the reverse being true for the fact goals.

![Figure 1](image-url)  
**Figure 1.** Mean proportion of unit selections made from each access facility.

Research with traditional text has shown that graphical overviews are superior to text outlines in facilitating students' ability to interrelate text content [Robinson & Kiewra, 1995]. The results of the current research are similar in that readers studying for information integration preferred selecting units from the content map indicating between-unit relationships. On the other hand, when the learning goal involved primarily information location (as with the fact goal), readers preferred the topic list even though the content map provided more information (i.e., allowed readers to both locate the needed information and see what other information was related to that topic). This suggests that when readers have well-defined learning goals, they take advantage of hypertext features which facilitate an efficient and focused learning strategy. It is interesting that there was no clear preference for one access facility with the application goals. This may reflect individual differences in the degree to which readers needed to consider a broad range of content as opposed to knowing what was applicable to the problems. It is also possible that a different type of access facility (e.g., organized around problem themes or typical problems) would have been preferable for this group [Hsi & Agogino, 1994].

Unit Selection and Review

Unit selection and review with hypertext has been shown to be influenced by both the reader's learning goal and the design of the hypertext access facility. Text review is most strongly determined by goal when readers have a well-defined study objective, as was the case in the current study [Dee-Lucas & Larkin, 1995]. The results of this research suggest that unit review is related to the degree to which the goal requires an understanding of the units in their entirety.

An analysis of the mean number of times a unit was read indicated that there was significantly more review with the fact and integration goals than with the application goals. For the application goals, readers needed to understand only the information required to solve the problems. For the integration and fact goals, readers probably needed to understand all or most of the units' content in order to adequately paraphrase the information and/or interrelate text concepts. Thus differences in unit review most likely reflect differences in the degree to which each goal required a complete representation of the unit content. The integration goals also required readers to generate relationships not explicit in the text, which may have prompted additional review. This finding is consistent with the results of traditional text research indicating that readers use text review to learn more factual information, and interrelate text content [Haenggi & Perfetti, 1992]. There were no differences among groups in the proportion of text units selected, or in the number of readers with each goal selecting each unit. This is reasonable because the three sets of learning goals all dealt with the same content.

Use of Self-testing Questions
Because hypertext gives readers considerable control over their learning, it is important that they monitor their text understanding. This process could be aided by self-testing questions (analogous to the questions at the end of the chapters of textbooks). The results of the current research suggest that hypertext readers limit their use of self-testing questions to those they consider relevant to their learning goal.

A multiway frequency analysis on the proportion of readers selecting at least one comprehension question and one application problem showed that few readers selected application problems, with no significant differences among groups. However, the comprehension questions were used more extensively, with over half of the Integration group selecting at least one question. Significantly more Integration readers selected a comprehension question than Fact readers, with no difference between these groups and the Application readers. An analysis of the proportion of application problems and comprehension questions selected by each reader in each group (for readers selecting at least one question) indicated that the Integration group selected significantly more comprehension questions than application problems [see Figure 2]. There was also a trend toward the Fact group selecting more comprehension questions than application problems (p<.07), with no difference between problem types for the Application group.

Figure 2. Mean proportion of self-testing problems and questions selected by each group.

The low number of readers selecting application problems indicates that no group thought that these would be helpful, even the Application group. This may be because many of these problems were quantitative, while the goal problems for the Application group were mainly qualitative in nature. However, it may also be the case that after reading the relevant units, these readers felt they understood the content well enough to solve the problems and therefore did not need to look at related examples. The lack of active use of these problems indicates that readers do not automatically use relevant goal-related learning aids provided in a hypertext. This is consistent with research suggesting that the cognitive overhead involved in using hypertext features that interrupt text processing (such as clicking on a word to see its definition) can deter use of these features [Wright, 1991]. The comprehension questions were used more extensively. Readers with the integration goals were more likely to select at least one question compared to readers with the fact goals, indicating that Integration readers felt it was important to have an accurate understanding of the units' main ideas. However, readers in both the Integration and Fact groups who selected at least one comprehension question used these questions more extensively than the application problems. These readers appear to have been checking their understanding of the units in the course of generating their responses for the learning goals. This is consistent with the unit review data in which these groups reviewed units more often than the Application group. These results suggest that readers will actively use this type of learning aid if it is perceived as being helpful for meeting the learning goal.

Note-taking

Note-taking from traditional text has been shown to aid memory for the information contained in the notes, primarily by providing a summary of the relevant text information for review prior to testing [Haenggi & Perfetti, 1992]. This type of learning aid may play a particularly important role in learning from hypertext by permitting readers to store key ideas from many units in a central location. In the current research, readers were
able to use their notes in answering the questions at the end of the experiment. The results indicate that in these circumstances, note-taking varies with the amount of goal-related content directly stated in the text.

The note-taking facility was used most actively by the Integration group. These readers took notes from significantly more units than readers in the Fact and Application groups, and included more idea units from the text in their notes (with no difference between the Application and Fact groups). These differences probably reflect the fact that the Integration group had to interrelate different units, and thus could clearly see the advantages of recording information from various text locations in one place. In contrast, the Fact group needed an understanding of the content within the individual units, and the Application group only needed to understand the specific content required for solving the problems. These results suggest that note-taking is useful for keeping track of and interrelating information from multiple text units when studying hypertext.

Strategy Effectiveness

One indication of the ability of readers to develop effective goal-specific study strategies is the extent to which they performed better on the assigned learning goals relative to the other goals. An analysis of the responses given by each group for each question set indicated that readers performed as well or better on the learning goals they were given in advance than on the questions received by the other groups. Thus they were able to generate goal-specific study strategies using the available features in the hypertext. However, there was a significant interaction between learning goal and the ability to answer each question set [see Figure 3]. This interaction indicates that readers studying for complex goals were able to complete the simpler learning goals as well, suggesting that the more complex learning goals required more thorough processing of the text content.

The Integration group had the most complex goal, requiring readers to interrelate different concepts in the text. This group performed significantly better than the other groups on the integration questions, but also performed as well on the fact questions and application questions as the groups receiving these questions in advance. Thus in studying to answer the integration questions, these readers took more complete notes (as indicated above) and mastered the content to the degree necessary to be able to answer factual questions and apply the content to solve problems. The Application group performed better on the application questions than did the Fact group, but did just as well on the fact questions. This indicates that studying for problem solving required a level of understanding sufficient for answering factual questions as well as information application. The Fact group received the simplest learning goals. They had to find and paraphrase information. There were no significance differences in performance on these questions, with the Fact group performing as well as (but no better than) the other groups. Thus the level of text processing required to answer the fact questions was not sufficient to allow readers to apply the information or integrate the content. This is consistent with research on traditional text processing showing that the types of internal representations developed for a text depends on the goals of the reader. For example, readers given a problem solving task will develop a model of the situation described by the text which will aid in applying the content; readers given the task of writing a summary will develop a propositional representation depicting the factual content of the text [Schmalhofer & Glavanov, 1986]. If readers are given a complex task requiring multiple levels of representation then they will be able to perform multiple tasks, as was the case with the Integration group and to a lesser extent the Application group.
Conclusions

The results of this research indicate that readers can use a hypertext effectively to achieve learning goals that vary in the depth and types of text processing required. However, readers relied on different features of the hypertext for factual learning, information application, and content integration. Readers studying for factual learning used the topic list when selecting units, and reviewed units more often than readers with the information application goals. This suggests a focused study strategy emphasizing a thorough understanding of individual text units or a subset of their content. In contrast, readers with information integration goals preferred the content map for unit selection. These readers were also more likely to check the comprehension questions than the Fact group, took more notes than both of the other groups, and reviewed units more often than readers with the information application goals. These findings indicate that the Integration readers were concerned with acquiring a thorough understanding of both the unit content and between-unit relationships. These results suggest that readers may find a variety of learning aids useful when studying hypertext with a complex learning goal such as information integration. The Application readers did not show a preference for either of the two access facilities and reviewed less often than the other groups. These readers appear to have relied less on the available hypertext features and possibly more on prior knowledge to guide text study, suggesting that the features provided by the hypertext were not particularly helpful for this learning goal. There may also have been a greater variation in the strategies used by readers to study for information application.

The study strategies used by the three groups resulted in differences in how thoroughly the text content was processed, as indicated by performance on the learning goals. Readers with the more complex goals were also able to complete the simpler goals. This suggests that hypertext processing involves the construction of different types of representations for the content, with different representations building on one another to produce a deeper understanding in a manner consistent with traditional text comprehension [Kintsch, 1986].

The results of this research indicate that readers are flexible in developing goal-specific study strategies for hypertext, and that different hypertext features support different types of learning. Further research is needed to determine how to design hypertext incorporating a variety of capabilities for individualized learning in order to support a broad range of learning goals.

References


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Abstract: We have designed and managed virtual learning environments that take advantage of emerging technologies in multi-media communication and capitalize on existing data and products from research. Our development, dissemination, and evaluation effort has involved multiple departments; promoted faculty-faculty, faculty-learner, and cross-institutional interaction; and concentrated on improving the quality of distance education offered via electronic media at the University of Minnesota. We showcase how we have worked to extend the land grant mission to varied audiences via virtual learning environments. In each case, we describe the audience addressed, the content delivered, the media used, and our results to date. We conclude with a discussion of critical issues surrounding the design and management of virtual learning environments used to extend the land grant mission.

Need for Multi-Media Modules

We are in the midst of a technological revolution in education, industry, and personal interaction. The American Society for Training and Development estimates that by the year 2000, 75% of the American workforce will need retraining (Carol Twigg, Vice President of EDUCOM 1995). Emphasis must be placed on non-resident instruction, particularly distance learning, in order to address this need.

While technologies currently used for distance learning (e.g., interactive television) can help address a wider audience, they generally require that the learners and instructors coordinate or synchronize their schedules and, often, that the learners must assemble at specific locales outfitted to accept such transmissions. Although certainly useful, these technologies do not address time constraints and other problems associated with the education of working, non-traditional students with lifelong educational goals. We feel that these goals are more readily addressed by a blend of asynchronous and synchronous educational models.

Self-directed, self-paced multi-media educational modules based on the World Wide Web (WWW) allow students, industry professionals, state and federal agency personnel, private consultants, and community groups to access these materials during times and at locations that suit their schedules. Furthermore, these modules address two unique characteristics of training in scientific and technical disciplines:

- Many of the concepts have strong visual and spatial components; and
- The students are at multiple and remote locations.

Design and Development of Virtual Learning Environments

We see the majority of these virtual learning environments as being developed by small teams of scientists and specialists from multiple departments, institutions, and community groups. In our case, we have collaborated with high school instructors, media center specialists, computing center personnel, and industry specialists in the design and development of these learning environments.

Together, we have investigated how these learning environments can be made scalable to multiple audiences representing a variety of needs for this information, and we have collected information on the costs and benefits of this development and dissemination effort. In our specific case, technical communicators interested in studying the
design and use of these modules have collaborated with agricultural scientists. Both groups have significant contributions to make: for example, agricultural scientists could provide the content of the modules, and technical communication specialists could apply principles of design and instructional and communication theory to the development and use of the modules.

Traditional educational experiences may be classified into three main components:

- information delivery, normally consisting of lectures and readings;
- mentoring, generally accomplished via discussion sessions or one-on-one meetings; and
- assessment, accomplished by exams, papers, or projects.

These traditional elements still exist in virtual learning environments, but they can be modified to take fuller advantage of the electronic media that are used. For example, information delivery may occur via World Wide Web (WWW) modules that contain much more information than normal textbooks or lectures. Linked graphics, video, sound, and hypertext provide a much richer educational experience than is available from texts. The use of hypertext and links allow instructors to provide additional information for concepts or areas of the modules where they foresee the potential for misunderstanding or potential lack of background preparation.

Likewise, mentoring may occur via listservs, email, or desktop videoconferencing, and assessment may be accomplished by virtual laboratories or other more realistic situations in addition to more traditional methods.

In the remainder of this paper, we describe the information delivery, mentoring, and assessment components of six projects designed to meet the needs of diverse learners.

Secondary Learners

In this century and the next, we must engage students in settings that motivate them to act and respond to other people. These settings will most often take the form of research partners or mentors and mentees. Asynchronous and synchronous virtual learning environments can enhance mentoring processes; mentor and mentee come to understand another perspective or participate in more advanced skills through a process of active learning and joint involvement in problem solving.

Soil Science: Virtual Research Partners

The audience for this project is an honors chemistry class in cooperation with their teacher. This project was established to incorporate ongoing research experiences in environmental chemistry into beginning chemistry education in order to stimulate student interest and provide real-world links to subject matter that is often perceived as being esoteric and pointless. By making the students into "virtual research partners" with the graduate students and technicians in the environmental mercury laboratory, we hope to provide them with meaningful insight into the application of chemistry to real-world problems.

The students will be exposed to all phases of the research, from the development of objectives and hypotheses, to experimental design, and finally to the results, and interpretation of environmental mercury research projects. Information delivery will be accomplished by hypertext and images placed on WWW pages, by discussions on a listserv, and by materials placed in an ftp site. Mentoring will be accomplished mainly by the students' teacher, but will also be enhanced via email and listserv communications between the students and faculty and graduate students working on the research projects at the University of Minnesota. Assessment of the student's comprehension of basic chemistry is not specifically addressed in this project; it is left to the students' teacher.
Technical Communication: Mentoring via Desktop Videoconferencing

To connect mentors and mentees across distance, the Rhetoric Department at the University of Minnesota has used desktop videoconferencing to link technical communication students with secondary students at local high schools. Essentially, we have taken desktop videoconferencing units originally designed for business applications—Cameo™ on the Macintosh platform, and PictureTel LIVE™ and Vistium™ on the DOS platform (for audio and video) over an Integrated Services Digital Network (ISDN™)—a narrow bandwidth phone line—and applied it to educational needs. College students have used this system to mentor secondary students in language arts, environmental biology, chemistry, physics, and interior design courses. By creating an interactive multimedia system that combines face-to-face communication and networking in one configuration, we begin to foster one-on-one connections that approximate face-to-face communication.

When 25 college students in an upper-level science course mentored 27 high school students in environmental biology (they discussed two case studies on the environment), we found that the sessions lasted an average of around 20 minutes and that the majority of conversations focused on the discussion of new information and options for the decision makers in the cases. We also found that: 100% of the mentors liked or strongly liked mentoring via desktop videoconferencing; 85% felt that such mentoring was very helpful for themselves; and 84% felt that it was very helpful for their students [Duin, Simmons & Lammers 1994].

In another study, we transcribed the college students' discussions with the high school students (via desktop videoconferencing) and compared these to discussions via email alone [Duin & Mason in press]. Although mentors reported that mentoring via email seemed to be easier or more effective, upon close examination of transcripts, we found that mentors commented a great deal more and across more categories when using the desktop videoconferencing system.

Post-Secondary and Graduate Education Learners

Soil Science: Online Field Trips

The learners in this project are resident and non-resident undergraduate and graduate students enrolled in Soil Science courses at the University of Minnesota and elsewhere. This project was established to introduce students to concepts of soil-landscape relationships, especially as they occur and are displayed across a wide range of landscapes and environments. This study focuses mainly on the information delivery component of the virtual learning environment, utilizing the multimedia aspects of WWW.

The WWW module consists of several rich cases, each containing descriptions and images of soil profiles, landscapes, geology, climate, vegetation, topography and topographic maps, and geological histories for each research site. Linkages between relevant bits of information, the concepts, and one or more interpretations of processes involved are provided. Mentoring occurs mainly via classroom sessions and email, and assessment is currently accomplished by traditional exams and papers.

Technical Communication: Document Design via Interactive TV and the WWW

The learners in this project are resident and non-resident undergraduate and graduate students enrolled in Scientific and Technical Communication courses at the University of Minnesota and elsewhere. Students attend class in an Interactive TV classroom and access all course materials from the WWW. Faculty and students in professional communication programs at universities in other countries access these same modules for use in their resident courses.

The modules contain descriptions of readers/users of technical documents, planning and tracking a project, developing and organizing information, collaboration, verbal and visual presentation of information, using multimedia, usability testing of documents, editing information, and copyright law. These modules also contain links to additional Internet sites that relate to this information. Mentoring occurs primarily through email and a class listserv. Instructors assess projects sent and received via the Internet. Instructors also forward projects to industry personnel for evaluation and comments.

Continuing Education Audiences
Soil Science: Regulatory Agency Personnel

Legislative emphasis on wetland conservation has created a demand for individuals, and especially state and county regulatory personnel, skilled at identifying hydric (wet) soils. In the past, retraining of regulatory personnel has occurred via week-long field and classroom sessions. We are currently developing a multimedia learning module on hydric soils to aid in that training. It is initially intended for non-resident regulatory personnel from the Board of Water and Soil Resources, State of Minnesota, and for resident undergraduate and graduate students enrolled in the Wetland Soils course at the University of Minnesota, and will be delivered by WWW. The main objective of the module is to teach basic concepts of identification of hydric soils. Much of this material is highly visual: images and descriptions of soil profiles, micromorphological features, landscapes, topography and digital elevation models, hydrological relationships between the soils, and native vegetation. Additional textual materials are included to guide the user through the module and to explain some of the more intricate concepts associated with hydric soil formation and identification.

Mentoring is accomplished by agency personnel and by email and listserv communications with the faculty. Assessment is accomplished by standardized exams and field assessment.

Technical Communication: Virtual Learning Center

Considerable legislative effort during the past decade has focused on the need for clear design practices that promote the development of understandable and usable documents. Personnel in a large variety of organizations (health organizations, banking and finance industries, computer industries, state and federal agencies, community groups) need training in audience analysis, media selection, and document design to ensure that their policies, procedures, proposals, and documentation packages can be accessed and understood by a wide variety of audiences. The large majority of those seeking training are not trained in scientific and technical communication, but usually have some background in human resource, management, or engineering fields.

Thus, this conference center (on the WWW) is intended for non-resident audiences in need of technical communication information. Currently "under construction," this site will provide information in areas such as: editing, visual communication, scientific and technical presentations, interviewing, training of technical communicators, audience analysis, media selection, designing messages, and rhetorical theory. Visitors to this virtual learning center may choose to access information or also continue learning through mentoring with faculty and listserv groups located at this virtual site. If learners choose to take any of the modules for credit or certification, their work will be accessed through online exams and papers/projects sent across the Internet.

Issues When Designing and Managing Virtual Learning Environments

Virtual learning environments create places where diverse communities can come together. When designing these environments, you should collaborate with people from disciplines other than your own. You should offer learners access to a variety of electronic forums:

- online lectures and interactive multimedia textbooks (WWW)
- one-to-one and one-to-many communications through email
- asynchronous group communications through USEnet news/discussion groups, limited listservs, or WebChat boxes
- synchronous group discussions through virtual meeting places such as MOOs or desktop videoconferencing connections
- forms on a Web page to create and grade responses online
- encryption programs to allow learners to send and receive files with greater knowledge that their work remains private and arrives intact

These virtual spaces allow learners to converse across the limits of time, distance, and space. According to a recent cognitive framework on proximate and distance communication, these electronic forums allow us to reach those in the world with whom we share relative similarity or with partners who are more cognitively similar to ourselves [Kaufer & Carley 1994]. These electronic forums enhance concepts such as asynchronicity, durability, and multiplicity. That is, these forums free learners from having to work at the same time, they secure the length of time that the content of a communication is available for interaction, and the number of communication partners that can be communicated with at the same time may grow exponentially.
You should use the WWW if your subject matter benefits from the inclusion of multimedia. Your development effort likely will take at least twice the amount of time as creating traditional or text-based materials [Barbieri & Doerr 1995]. To learn hypertext markup language, estimates range from 1 to 6 hours to learn the basics. If you wish to track the use of your WWW pages or have learners submit comments, responses, and questions from your WWW pages, you will need to collaborate with others to write scripts. Thus, in essence, you will most likely need to collaborate to develop and implement your WWW pages.

To meet learner needs, information should follow sound instructional design [see McManus 1995, and sound document design principles. A great resource for document design principles is the Web Style Manual at the Yale Center for Advanced Instructional Media (http://info.med.yale.edu/caim/StyleManual_Top.HTML). To meet and exceed your learners' needs, please also do the following:

- identify the purpose of your module (i.e., provide instructional objectives), the primary audience for the training, and expectations by way of experiences or learner outcomes;
- describe how learners will assemble (e.g., by listservs, MOOs, desktop videoconferencing) and what type of communication and collaboration is expected or is not allowed;
- describe the origin of the material, past uses of the information, copyright free uses of the information, and uses that would infringe upon copyright;
- introduce the instructor / trainer / facilitator / guide / tutor and provide access for human contact with this person;
- provide alternate routes (links) through the material based on different abilities (novice, intermediate, or advanced learners), different learning styles (linear, nonlinear), and learners' prior knowledge and experiences (e.g., consider whether metaphors or examples will be understood across cultures); and
- allow learners to customize the information to meet their needs.

You also need to provide a secure and reliable distance learning environment.

When learners engage in conversations with others in their learning community, they need to know that their conversations are secure, private, and authentic. If the instructor asks for discussion, either by WWW forms or a listserv, then participants must feel secure that outsiders will not be able to access their ideas and private conversations. Furthermore, for assessment purposes, some form of encryption is needed to both guarantee the integrity of a student's work and to authenticate its authorship.

Additional issues include:

- Hardware / servers / connectivity needed to secure a site on the Information Superhighway.
- Technical support personnel for system administration and maintenance.
- Human resources for technical and design support of the modules as well as contact with those who visit the virtual learning sites.
- Access to high end computers by faculty, staff, and learners. Although the WWW can be accessed via Lynx, the modules we have described depend heavily on an understanding of information via a visual / multimedia presentation.
- Unit support as high as possible. To design virtual learning environments that move well beyond the provision of information alone, you need support from upper levels of your administration. These people need to understand the needs of non-resident learners.
- Maintenance support for on-line materials. Links to materials resident on other servers may die; material changes over time; and references / images / concepts need to be updated.

As we deal with these issues and design virtual learning environments, a new landscape will emerge. Learning modules, available to diverse learners and customized on demand, will result in global education. Education will be dispersed, collaborative, in need of teams of learners in support of one another, and armed with a deep commitment to learning, a deep sensitivity to cultural values, and an overriding sense of learning as encountering a new sense of our land grant mission.

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The Flashlight Project: Developing Tools for Local Assessment of Educational Strategies and Technology

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Abstract: The Flashlight Project is developing survey items, interview plans, cost analysis methods, and other procedures that educational institutions can use to monitor the success of their educational strategies that use technology. The instruments have begun beta testing at five institutions that, previously, helped to develop their design.

The Problem

Institutions are investing enormous amounts of effort, money and risk capital in computing, video and telecommunications. (As are their students.) One motive for the institutions is to enable changes in their educational strategies and thus to changes in educational outcomes. For example, institutions may invest in extensive infrastructure for electronic mail in hopes that it will support more collaborative learning and more use of information resources off-campus, ultimately fostering better retention, economies of scale, and graduates who are more able to apply what they’ve learned. Technology is easy to observe -- one can see whether the e-mail and Internet systems are operating or not. But is there more collaborative learning? Are graduates in fact working more competently in teams? And if one hears that these objectives are being attained at institution X, does that imply that one’s own institution has succeeded, too?

Education, like politics, seems to be mainly local. Knowing what has worked, or failed, elsewhere may inform an educator’s imagination, but it says little about what might be working, or failing, locally. There is no substitute for doing one’s own evaluation. And with so much at stake, there is little excuse for not “knowing thyself.”

Nonetheless, evaluation is easier preached than implemented.

Doing an educational evaluation is like using a small, dim flashlight to find one's way in a large dark cave. The relative brightness (rigor) of the flashlight (evaluation) is much less important than where one points it (asking the right question). Any evaluative procedure is designed to answer some specific question in a particular way. It is, for example, useless to ask "How successful is technology in improving education" because that curiosity is too broad to translate into a meaningful evaluative study. In order to get a useful answer, one must first ask the right question.

Here we hit a happy coincidence that is the genesis of the Flashlight Project. It appears that while the answers to our educational questions may be local, the questions are often global. Very different institutions are adopting quite similar technologies for quite similar reasons. Because this is true, and to the extent it is true, they can use quite similar evaluative tools - survey items, interview guides, cost analysis methods - to ask their questions.

The Flashlight Planning Project, 1993-94

The goal of the original Flashlight planning project was to discover whether five very different postsecondary institutions were in fact using comparable educational strategies to deal with some of their most serious problems, and using technologies in a comparable way to implement those strategies. If that were true, then it should be possible to develop a limited set of evaluative procedures that would be of wide usefulness. We wanted to see whether we could agree on a set of outcomes limited enough and specific enough to provide the foundation for such a set of evaluative procedures.
Each of the five disparate institutions (see “The Participants” below) delegated a two member team -- one faculty member and one administrator -- to participate. The author prepared an initial working paper and a two round Delphi study by which the participants fine tuned the model. The effort climaxed in a two day working meeting in which participants made final decisions about elements of technology use, educational strategy and educational outcomes that were of common concern. In other words, they identified a set of shared hypotheses about how computers, video and telecommunication could enable change in educational strategy, and thus in outcomes -- hypotheses that were already in use at all their institutions.

Armed with these hypotheses, Flashlight’s next task was clear -- develop evaluative procedures that would be simple and inexpensive, yet adequate to help departments and institutions track their own implementation of these new strategies and to monitor whether or not the hoped-for outcomes were indeed occurring.

The Participants

These five distinguished and distinctively different institutions of higher education that shaped the model and that are currently testing the first drafts of some of the Flashlight instruments are:

- one of the largest community college districts in the country (Maricopa Community Colleges),
- a public institution that offers a state-wide, virtual community college program supported by a combination of video, computing, and telecommunications (Education Network of Maine);
- a major land grant institution with innovative programs exploiting technology for students on- and off-campus (Washington State University -WSU);
- an institute of technology with a national record in both distance learning and services for the handicapped (Rochester Institute of Technology -RIT; and
- a public university that exemplifies institutional partnership at virtually every level (Indiana University - Purdue University at Indianapolis - IUPUI).

Leading the development of the student, faculty, alumni, and alumni supervisor survey items and interview guides is Robin Zúñiga of the Western Cooperative for educational telecommunications. Leading the development of the cost analysis measures is Joe Lovrinic of IUPUI. Rounding out the team are Sally Johnstone of the Western Cooperative and Trudy Banta of IUPUI.

The Structure of Flashlight

The Project is developing a survey item bank and interview guide for each of four sets of potential respondents: students in a course of study, their faculty, alumni of that course of study, and their supervisors.

A second set of instruments are being developed for doing cost analyses.

Third, the Project is collecting a set of research designs that should help institutions ask the right questions about their evolving strategies.

It is not possible in this short paper to describe the issues that Flashlight will track in detail, but here are a few of the key areas:

- The educational strategies of greatest interest include enhanced project-based learning, collaborative learning, and faculty-student interaction.
- Student time on task is one of the key intermediate variables, since it so often can predict learning.
- Access variables include student location (relative to the campus), time demands, and native language.
- Learning outcomes for graduates include demonstrated ability to apply what was learned in the academic program, to work in teams, to use information technology appropriately and creatively in one’s work, and to manage one’s own process of continuing learning.
- Cost outcomes of greatest interest include (for large distance learning programs) capital and operating costs relative to comparable programs on one’s own campus, and savings in costs per graduate coming as a result of (hoped-for) increases in retention.
Project Status

At this writing (February 1996) the student survey item bank and interview questions have begun their first round of beta testing. The cost analysis strategy is under active development, as is the faculty survey item bank.

Outreach plans are still at an early stage. The Flashlight Project has been working especially closely with the Teaching Learning and Technology Roundtable program of the American Association of Higher Education. We hope to offer a series of train-the-trainer workshops through the Roundtable’s regional meetings. Use of videoconferences and on-line seminars is also being considered.

For up-to-date information on Flashlight, including more detailed descriptions of the model and background articles on educational research, evaluation and technology, see http://www.learner.org/ed_strat/ed_eval

Flashlight also has a listserv on which we periodically post announcements about project progress and strategy; the good news is that you'll get only 3-4 messages a year! The way to subscribe to F-LIGHT, the listserv about the Flashlight Project, is to address e-mail to LISTPROC@LISTPROC.WSU.EDU with the one line message SUBSCRIBE F-LIGHT (your name)

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The Web as a Student Communication Medium:
What's Different?

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Abstract: With the goal of exploring the usefulness of the World-Wide Web as an aid to class infrastructure, a variety of classroom functions were carried out through web pages in two undergraduate courses in the MIT Media Lab. This paper describes the structure of the courses and analyzes the different behaviors and communication styles that arise from using the web instead of traditional classroom methods.

Introduction

Much work has been done to incorporate the World-Wide Web into classroom life by using it as an information resource or by using it as a basis for long distance collaborative learning [WWW’94; Virtual Library]. In our courses we* were interested in using the web to replace some of the routine activities of any individual course. We will describe the structures and goals of the two courses, introduce the concept of information flow, and then discuss the differences that arose as a result of using the web instead of traditional classroom methods. Using the web encourages both different styles of learning and different behavioral roles for the students and teachers.

The Courses

Both courses were undergraduate offerings in the MIT Media Lab. One was MAS134 Story: Representation and Process (hereafter called Story), a course that analyzed the representation of information in hypertexts, images, film, and television, as well as teaching the students how to manipulate each medium. This class was taught by Professors Haase and Davenport with the author as teaching assistant. There were 16 students. The address of the home page for this class is http://mas134.www.media.mit.edu:8001/.

The other course was MAS123 Tools for Thought, a course that focused on the type of knowledge that is embodied within various systems with which we interact. The “tools” with which we interact with a given system often contain artifacts of the knowledge assumed within the system. Systems included physical world (in which we use tools like hammers and toasters), the domain of complex systems (in which we use simple generalizations to understand a situation that contains thousands of variables, like traffic patterns), and the domain of language (in which we use a set of common assumptions to understand each other). This class was taught by Professors Resnick, Brand, and Cassell, with the author as teaching assistant. There were 14 students. The home page for this class is at http://mas123.www.media.mit.edu/courses/mas123/.

Two main goals for web use in the courses were to encourage more sharing of ideas by having student presentations readable by all the students and to encourage better integration of the course material throughout the semester by having all past projects easily accessible. Thus, all

* The use of “we” throughout the paper refers to the author as well as the Media Lab faculty who designed and taught the courses described below: Professors Ken Haase and Glorianna Davenport in MAS134 and Professors Mitchel Resnick, Matthew Brand, and Justine Cassell in MAS123.
student projects were "turned in" on the web. Although project presentations were usually presented 'live' in front of the class, they were recorded with video or photograph and then archived on the web post hoc. In Tools for Thought we also focused on the students' learning through the process of building hypertexts (an activity which can encourage a stricter organization of one's ideas than a linear essay) and through indexing each other's pages (an activity which illustrates which ideas are related). Gordin et al. [submitted] give a good summary of the advantages of such practices and of networking within classes and schools in general.

Note that having all students' assignments available to the entire class raises a privacy issue. We did not make grades public (which we considered a blatant violation of privacy), but all the student work did include the students' names. This situation (as opposed to anonymous displays of work, for example) could be seen as unduly pressuring the students to do well in front of their peers. We concluded that this pressure was not as severe in our courses since the assignments and presentations were all relatively creative or based on the interpretation of texts. Such pressure would be significantly higher in a course that demanded exact answers. Making all responses to a physics class problem set public, for example, could be severely embarrassing for a student who was not able to complete it.

Our Setup

In Story, each student had a computer account on the Media Lab's UNIX network. Any files that the students put in a certain subdirectory within their account could be seen by the web server. In Tools for Thought, we had only two user accounts, one for faculty, and one for students. The students had their own directories within the one student account, but all files were changeable by any student. This system was easier to maintain for a web environment, but it required mutual trust on the part of the students. The system worked well despite our doubts, perhaps because students had computer accounts on the campus network where they could do most of their work before copying the final files to the Tools for Thought student account.

In both classes the students were familiar with at least basic UNIX commands already, but many had to learn HTML (the language for writing web pages). We gave the students access to an image scanner and encouraged them to use it to make images for their pages, but the recently growing trend of deeming web images of prepublished graphics to be copyright violations has made the scanner somewhat less important. (A reader outside of MIT will be unfortunately unable to view those projects on the current course web pages in which students used prepublished images.)

Information Flow

There are basically three types of people that interact in a classroom setting: teachers, students, and outsiders. The outsiders usually play a smaller role in the course, and might be principals, parents, other teachers, or students from other classes. We categorize different types of communications between these three groups of people as different types of information flow. A typical course contains both one-way flows, like a lecture, and two-way flows, like classroom discussions (See Figure 1). The different information flows described below are parameterized by the type of person involved (student, teacher, or outsider) and by the chief directionality of the flow (one-way or two-way). Note that by labeling the type of communication that is taking place, an information flow also describes the roles that the participants are playing.
We suggest that any class could be described as containing most of the information flows below, though the percentages of each flow differ across classes. It is exactly such a difference that we see in our web-based classes when they are compared with traditional classes. Because the web more easily accommodates some information flows over others, we noticed that those types of communications and their corresponding behaviors prevailed in our classes. Below we describe different types of information flow and note the web-based behavior differences in terms of each one.

One-Way Flows

**Administrative**: Teacher $\rightarrow$ Student
This category includes assignments, notices about upcoming classes, and various other logistic information. Because these forms of information are usually textual, they can easily appear on the course web page. The syllabus, the list of readings, and the assignments were all available online. In *Tools for Thought* we also had a "What's New" page that was updated weekly to hold the most relevant subset of the administrative information. We were hoping to spend less time in class on such administrative issues by having this material on-line, but we found that it was nevertheless best to introduce each new assignment "live" in class, simply because students often had clarifying questions about them.

**Podium**: Active Teacher $\rightarrow$ Student
This category consists usually of lectures that a teacher gives and that one or more students absorb. The term "active" implies that the teacher is trying to convey specific information with the presentation. Most traditional classes contain a large percentage of Podium communication, and ours did as well, though we also had many Discussions (see below). Because the web doesn’t easily convey high-quality video yet, Podium information on the web might consist of copies of a teacher’s lecture notes.

**Poster**: Passive Teacher $\rightarrow$ Student
This category is defined by information sources which are meant to be browsed or skimmed over more than carefully attended to. A traditional example would be a poster of the solar system that appears on a classroom wall. A teacher might place it there to arouse general curiosity rather
than to convey specific facts. Eye-catching graphic icons that play a similar role are easy to include in web pages, and satisfying the desire for further information is much easier (simply clicking on the icon) than in the classroom (looking something up or asking someone).

The display of students’ past work can play a similar role, in that the teacher may hope that students keep in mind what they did in the past as they work on their current project. While such presentations of past work often take up precious wall-space in a classroom, it is always easy to add more web pages.

**Report**: Student → Teacher and/or Student → Student
This category includes the various presentations that students make, such as homework, term papers, or spoken project reports. Like the Podium presentations, these can be put on the web with varying degrees of ease. Note that on the web, however, all presentations can be made viewable by all the other students as well as by the teacher. This condition rarely occurs with term papers or homework in a physical classroom.

**Showcase**: Teacher and/or Student → Outsider
Though rarer, this form of presentation often can be seen on the walls of a classroom before parents visit. Teachers and students may both participate in displaying examples of past work in a form that can be understood by outsiders. A similar process takes place if a teacher creates any sort of archive of the class, either for his or her own future reference, or for the use of future teachers. This type of information flow is significantly different than the Report style in that an archive usually assumes less knowledge about the class. On the web, the teachers and students will adjust the interface and link structure of their web site before they make the site public and Showcase their work.

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**Interesting themes in your toy analyses**
(I’ve put an occasional summary, edit or response of mine in [brackets].)

**Melanie Jones** (action figure transformer/drama stage)
- [toys for storytelling...make reference to known narratives (movies)...serve as mnemonics for specific scenes in the movie...allow the child to work out alternative plot lines]
- Very important is the idea of an ENCLOSED world, a complete world in miniature. This is a finite space over which the child has complete control.
- These toys are particularly clever because they took this idea of an enclosed world and made it LITERAL. The child can actually close up their world with the characters inside and carry it (or wear it like a necklace). There’s a definite feeling of satisfaction and control to that.

**Max Robertson** (tensegrity construction kit)
- provides a concrete illustration of these two fundamental physical principles...building with it, children (and adults) can actually feel the forces acting [and becoming part of the structure’s dynamic equilibrium].
- kinesthetic understanding of structures

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Figure 2: An example of Feedback; Professor Brand summarizes student responses by quoting and linking directly to them on a web page (student names changed).
Two-Way Flows

Feedback: Teacher <-> Student
In a class this type of flow could happen when a teacher summarizes the general trends within the latest series of student projects, and the students add their own opinions. On the web this form of exchange can arise when a teacher critiques student projects and includes links directly to them. Professor Matthew Brand gave particularly good feedback by building web pages that quoted a salient idea from each student’s response to a given assignment. An excerpt from such a page is in Figure 2. On it he summarizes the overall themes in the student responses, and then quotes (and comments on) some of the main ideas from each student’s paper. Because the student papers are on-line, he can link directly to them as well. The Covisualization Project at Northwestern University reports a similar process with its web-like school network [O’Neill and Gomez, 1994].

To some extent this summarizing process is harder for the teacher, in that he or she must consider the student projects as a whole, as opposed to grading the individuals alone. Indeed some teachers expressed frustration with the inability to scrawl comments in the margin of a student’s “paper” in traditional fashion. In terms of educational value, though, the ability to synthesize the students’ responses so easily was seen as a great advantage. A teacher could always print out a copy of the web page if he or she wanted.

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...It seems that the exploratory stage used by many of the groups led directly into a decomposition-type of solution. (Jeff) pointed out that “…we didn’t know we were going to construct this device until the concept manifested itself from seemingly non-connected parts.” (Matt) notes that “as apparently useless as they seemed on their own, these (the smaller individual constructions) would eventually become the building blocks for the machine.” I find this aspect very interesting as it is typically assumed, and was noted by (Neil) that we can’t build a tool unless we know what we’re building first. ...

Figure 3: An example of Discussion; a student links directly to other students’ work

Discussion: Student <-> Student
This flow of information happens most in class discussions as students propose ideas based on others’ ideas. Teachers can also take part, but only on a non-leadership basis (otherwise it becomes Feedback). On the web, this behavior can be seen when students react to each others’ web pages or include cross-referencing links between them.

In Tools for Thought, we asked students to make journal entries on each topic of class discussion. We encouraged them to make links to other students’ journal entries along the way if appropriate, but often, because doing so requires some careful reading of the other entries, students didn’t make such links until assigned specifically to do so. We later gave the "Associative Trail" assignment, however, which did mandate making such links; students were told to pick a theme from the course and write a web page that analyzed how all course participants discussed the theme in their journals. An excerpt of one student’s Associative Trail can be seen in Figure 3. In this excerpt the student reports on the thought processes that he and three others experienced as they worked on an assignment to build “a calculating machine” with a kit of toy gears.

We also offered students a web page that displayed accumulated comments on a certain topic and allowed the reader to add comments, simulating a USENET news group or mailing list. The idea was that students and teachers might hold a discussion on the page over a period of weeks, with new comments being added whenever someone had time to read the latest opinions. This interface was hardly used, however, because (most likely) many students talked with each other around the building anyway, and they could talk with teachers before and after class. The discussion web page seemed unnecessary. Some students did find the scripts that created this
comment page useful in their own pages, however; they could use them to allow the reader of a particular journal entry to make comments or annotations on that entry. The comments would then appear inserted within the author’s original text.

Although many see the web as a boon to remote collaborative learning, we found that despite excellent technological resources, collaborative learning happened most naturally when students were in the same room together. When students in Story had the assignment to write a hypertext narrative, for example, they reported exciting collaboration as they worked in a cluster of several computers; students would ask for comments from each other and learn from what other students had created. Similarly, when the students in Tools for Thought had an assignment to build a simple robot creature out of building blocks and a small computer, they learned from each other mainly because they worked together in the same robot lab.

Conclusions: What's Different?

We see the main differences between a traditional course and our web-based courses falling into two categories: different learning methods and different roles on the part of the participants. In terms of learning methods, we believe that the assignments to write hypertexts and to cross-reference them with other hypertexts led students to think more broadly about the issues at hand than they might have in a course in which each student works independently from others. Also, we suggest that having a permanent and easily accessible record of past projects (both a student’s own and those of others) leads to a better apperception of the overall themes of the course; traditional courses often allow students to forget each assignment after completing it.

In terms of the different behaviors that arose, having an archive of past projects can not only encourage positive peer pressure among students to be creative as each develops his or her own portfolio, but also let the students play a role as critic, commenting on each others’ projects. From the teachers’ point of view, the web allows one to give very customized feedback to student presentations. The teachers usually found it easier to evaluate students at the end of the term as well, since all the students’ work accumulated on the web.

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Acknowledgments

This paper would not have been possible without the thoughtful planning of the courses by Professors Ken Haase and Glorianna Davenport (Story) and Professors Mitchel Resnick, Matthew Brand, and Justine Cassell (Tools for Thought). Thanks also to Professor Whitman Richards for comments.
Support for Cooperation in Smalltalk

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Abstract: We justify the need for support of team work embedded into the VisualWorks Smalltalk environment and describe some aspects of its implementation.

Background

Smalltalk is a combination of a pure object-oriented programming language and an environment for browsing, extending, and executing a large class library. Initially designed as a stand-alone environment which the user never needs to leave to create, compile, link, and execute applications, all subsequent releases of Smalltalk retained the ability to fully sustain a student or an expert developer. Invented as an experiment in a new programming paradigm and a research tool for exploring how children could learn to actively use computers, Smalltalk has recently become the second most popular object-oriented programming language in the software industry.

Smalltalk is an excellent language to teach principles of object-oriented programming because of its purity and conceptual and technical simplicity, and because of its outstanding tools for browsing the extensive library of classes, for creating graphical user interfaces, and for application development. Moreover, products such as ENVY extend the environment by supporting team application development with individual ownership of classes, version management, and configuration management, making it a widely used application development tool for experts and perfectly suited for advanced courses. Since Smalltalk has been accepted as an industrial strength environment, several companies including IBM (product called VisualAge), ParcPlace (VisualWorks), and Digitalk (Smalltalk/V)\(^1\), developed their own versions of Smalltalk, and the growing interest and intense competition led to rapid advances and an increased interest in using Smalltalk in teaching.

The current leading Smalltalk products implement or will soon implement support for all features required by the software industry including visual creation of programs (programming by ‘wiring’), support for networking, access to WWW, distributed objects, and others. In spite of the richness of their environments, none of the existing Smalltalks provide direct support for synchronous or asynchronous communication between users. While teaching the language and its use in application development we found that this feature would greatly enhance the effectiveness of the learning process. Moreover, communication between developers within a team would greatly improve the development facilities as well. In this paper, we describe a collection of classes called MESSIAH (acronym for MUD-based Environment for Sharing Smalltalk Ideas, Applications, and Help), an extension of ParcPlace VisualWorks to support synchronous and asynchronous communication, and some of its anticipated uses in educational settings.

Typical Uses of MESSIAH

In this section, we describe several educational scenarios to justify the need for the environment that we are implementing.

Introductory Level Teaching of the Smalltalk Programming Language

\(^1\) ParcPlace and Digital recently merged into a single company and are developing a new version of Smalltalk combining the strong points of their respective current implementations.
Some students find Smalltalk difficult to learn because its full reliance on the OO paradigm is initially difficult to internalize. Beyond this paradigm problem, Smalltalk is difficult to master because of its very large class library containing over 1,000 classes and over 20,000 methods (message declarations). Finding the desired information in the library and learning to use it effectively is a problem very similar to the ‘lost in space’ navigational problem of hypermedia systems. Finally, Smalltalk’s environment support tools (browser, inspector, and debugger) are very powerful and their richness also presents a problem for beginners. When all these obstacles are added together, it becomes obvious that a combination of direct tutoring combined with peer-to-peer and peer-tutor communication within the Smalltalk environment would greatly simplify the learning of the language and the environment.

As a typical example of how such an environment could be used, students and instructors should be able to exchange messages with sample code accompanied by comments and questions, and obtain replies in a synchronous (‘view and respond immediately after sending’) or asynchronous (‘view and respond when logged in’) manner.

Beyond sending textual messages and returning textual replies, students and instructors should also be able to share whole windows of Smalltalk code obtained from the environment tools or view and edit them together.

Application Development Level

In a course on object-oriented program development, members of a team typically divide responsibilities for designing and implementing an application so that individual programmers are responsible for creating separate classes with previously agreed message interfaces. However, even in a well designed application, little details are often found which were left unspecified and which require communication between team members responsible for their development. Moreover, application development in Smalltalk can benefit from instantaneous testing of newly developed code (in Smalltalk, there is no separate compile-link process) and Smalltalk programmers use this technique extensively. In the present state of the environment, communication between members responsible for complementary cooperating classes requires members of the team to walk over to the station of another team member, and discuss the question verbally. This annoying detail requires that all members of the team be present in the room at the same time which is often difficult in an educational setting, and the practice is disruptive both in educational and industrial settings. Team communication would be greatly simplified if synchronous and asynchronous communication were built directly into the VisualWorks environment.

On-Line Support

Given the enormous size of the VisualWorks library of classes, most programming tasks can be implemented in very few lines of code, reusing the code created and tested previously. However, the size of the library is also a disadvantage because no single programmer can be familiar with all its components and their exact operation. Both beginners and advanced users would thus benefit from on-line support built into the environment. We have implemented such on-line support for a single user [Tomek 95] but what is needed is a shared resource which all users can access ‘simultaneously’ to pose questions, formulate and store answers, and record new experiences.

Implementation of MESSIAH

As the name MUD-based Environment for Sharing Smalltalk Ideas, Applications, and Help indicates, MESSIAH is based on MUD - Multi-User Dialogs or Multi-Users Dungeons. MUD is a concept that sprung up on computer networks in 1979 and evolved from a multi-user gaming environment into an interesting social phenomenon. This was noticed by social and computer scientists, stimulating research that led to a number of educational and office MUD based environments.
Most existing MUDs implement the multi-user concept as text-based simultaneous network connections which provide access to a shared database of ‘rooms’, ‘exits’, and a variety of other objects. The database and the software are stored on a central server which is accessed over the network by users via their client software. Users manipulate and browse the database as player personalities, interacting with the environment via text commands - manipulating objects, communicating with other players, and moving between rooms via exits that connect them. MUDs thus provide a form of virtual reality which, while lacking sophisticated multimedia aspects in most cases, offers synchronous and asynchronous communication between the players.

The MUD concept is directly relevant to the solution of the problems outlined in the previous section, as well as industrial environments such as automated offices. While most existing MUDs are based on a combination of an relatively simple client program residing at the user’s computer, a network connection, a database, and a server parsing and interpreting users’ commands and accessing the data base, the approach that we chose is more narrow and more general at the same time. In particular, the essence of our solution is that access to MESSIAH is from a ‘head-full’ Smalltalk environment (a Smalltalk environment with a graphical user interface) running on the user’s platform, the server is a ‘head-less’ Smalltalk process with no user interface running somewhere on the network. When a user logs into MESSIAH via his or her head-full Smalltalk session - client software, MESSIAH establishes a connection with the running server process and the user can then start sending messages as shown in Figure 1.

![Diagram](image)

**Figure 1:** In MESSIAH, users communicate with one another via a server. Communication indicated by arrows is in the form of executable Smalltalk messages.

The server maintains a queue of connections to the currently logged in user stations and services them in a round-robin fashion. The protocol of communication between clients and the server assumes that all messages are syntactically correct Smalltalk messages. As a consequence, neither the clients nor the server need any additional intelligence beyond that of the built in functionality of the regular Smalltalk environment which is already capable of direct interpretation of all Smalltalk code.

On the foundation of this framework, we are building other layers that will make it possible to allow communication between the client and the server that appears syntactically unrestricted from the perspective of the user. To achieve this, specialized applications - such as mail or help access - will be packaged by the superstructure layer of MESSIAH into Smalltalk messages which are still the expected form of communication by the foundation layer protocol, and the server will then process these messages in the usual way, using its own application layer as the destination classes as shown in Figure 2. The same translation can occur in the opposite direction in communication between the server and the client.
Figure 2: Application layer allows arbitrary form of communication while network communication between clients and server is in Smalltalk.

Conclusion

In the first phase of our project, our implementation is limited to communication of textual information, resembling most existing MUDs. Its function will thus be limited to mail-like synchronous and asynchronous communication and access to the help system. Communication of other forms will be addressed as the next topic. Sharing of windows containing Smalltalk code will be an interesting problem which we have not addressed so far. The difficulty here is that although two different users share the bulk of the class library, differences in details make one user’s library incompatible with the library of another user thus making some code valid on one user’s platform invalid on another platform.

The state of MESSIAH at the time of this writing is as follows: We have implemented the basic communication tools based on the implementation of sockets in VisualWorks and completed the requirements specification, analysis, and design of MESSIAH. We expect to complete several application layers during the summer.

References

The Impact of Learning Pathways on Performance in an Interactive Multimedia Learning Environment

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Abstract: Interactive courseware benefits learners to access information and tools by which they can construct personalized transitions between the information to be accessed and their own cognitive structures. The process of navigation enables learners to experience the content of interactive courseware. Learning pathways also reveal the learning trails while learners traverse any interactive environment. Since learners have unique knowledge structures based upon their experiences and abilities, the ways that they choose to access, interact, and interrelate message in interactive courseware also very. Studies on pathways help us to explore and explain human behaviors during learning processes. The aim of this study is to answer two research questions: (a) do learners use the guided discovery hypermedia differently? and (b) what relation do pathways have to learning performance? The researcher made an inventory of exploratory learning processes by analyzing learners' navigational data recorded in computers. Frequency and duration of each nodes in learning pathway were identified and calculated. Null hypothesis were tested and conclusion were made.

Background of the Study

A better science education is demanded for all children who are supposed to enter a technologically and scientifically advanced society [Guskey & Passaro 1992]. The U.S. Department of Education and the National Science Foundation [USDE & NSF 1992] endorsed a shared statement that science and math instruction should promote active learning, inquiry, problem solving, and cooperative learning of students. This perspective reflects the constructivist approach which learning is the result of mental changes while we make meaning out of our experiences [Osborne & Freyberg 1985]. It seems that the passive expository teaching method or reception oriented learning approach could not completely meet the needs of science instruction. Current theories on learning focus on the "active agent" role of learners who do not passively receive message delivered via instructional channels but who do actively explore phenomena and construct knowledge by themselves. The notion of exploratory or discovery learning is well known over the years but has recently received renewed attention via the usage of interactive courseware. Interactive courseware provide us with adequate supports and stimulated features which inspire learners with active, constructive attitude toward message/activities embedded in courseware and encourage them with engagement of meaningful incorporation of information into their existing cognitive structure. Hence, multimedia is an optional approach to provide ideal learning opportunities. This study tries to shed some light on discovery learning processes and the effect of learning pathways on performance. At the present time, what we know about courseware design is much more of an art than a science [Laurel 1990]. If hypermedia/multimedia courseware are going to live up to the great promises that are being made for them, our knowledge of design factors regarding the learners' cognitive and operational perspectives of these courseware must be strengthened.

Instructional Methods and Media

Learning is a change in an individual caused by experience [Mazur 1990]. The major weakness of traditional instruction is that it focuses on knowing 'what' rather than understanding 'why' and 'how' [Spiro et al. 1991]. Jean Piaget advocated the importance of learner-directed experiences. He also noted that it is so difficult for teachers to provide thought-provoking questions and follow-up learning activities. On the one hand, too much teacher mediation results in removing self-discovery opportunities. On the other hand, too little teacher guidance and direction can leave learners without the means of discovery. Guided Discovery method gives us a better choice. After a series of investigations on human learning in the middle 1960's, Bloom [Bloom 1971] recommended the
famous "mastery learning theory" that all student could learn well if provided with enough learning time and with individualized prescriptions/correctives as well as enrichment activities. The key feature of mastery learning is a series of unit formative evaluation (or quiz) and individualized correctives. Therefore, mastery learning is too difficult to implement in classroom teaching.

Methods and media are facilitators of meaning-making and knowledge-construction of learners [Jonassen et al. 1994] [Kozma 1991] [Kozma 1994] [Salomon et al. 1991]. Instructional media and methods are mutual influenced. Methods take advantage of media capabilities [Kozma 1994]. Certain media attributes enable certain methods [Reiser 1994]. Different instructional media make different types of learning activities possible by providing various learning support. Multimedia/hypermedia provides concrete context and especially benefits for learners who are unable to image learning context from abstract representation [CTGV 1992]. Therefore, the new instructional media, multimedia/hypermedia, empower the symbol systems and mental processing capabilities of learners. However, it is only when we make explicit use of new natures of multimedia/hypermedia that the instructional media would add multiple value to human learning. In computer-based guided discovery learning context, sufficient background information is provided, formative evaluation activities are presented, individualized correctives are arranged, and useful guidance is presented frequently while in the process of discovering. Computer-based interactive courseware give educators an alternatives to adopt mastery learning and guided discovery learning approaches into teaching and learning processes.

Despite the popularity of computer-assisted learning, there is little empirical research on discovery learning with interactive courseware [Litchfield & Mattson 1989] [Maor 1991] [Rivers & Vockell 1987] [Shute & Glaser 1990]. Past studies emphasized performance measures, not process measures. Only a few studies focused on guided discovery learning methods in computer-based environment. The need for research of this kind is important.

**Interactivity via Interfaces**

The innovation of computer-based interactive media as a new kind of instructional vehicle tries to make learners active constructors of knowledge, rather than passive recipients of knowledge structured for them by others [Papert 1990]. The interaction between a computer-based instructional system and its learners can be influenced by both the system itself and the engagement of the learners. The idea of learning interactively means that the learner is an active participant in the teaching-learning process [Jonassen 1985]. Learner interact with the learning activities of any instructional media/technology to construct a mental representation (symbol) of the specific domain and to make inferences based upon representation processing. The major advantage of interactive learning materials over other instructional media lies in the unique feature of interactivity. Maximizing the effectiveness and efficiency of learner-courseware communication, i.e., interactivity, leads to increased learner satisfaction and to enhanced performance and productivity of learning materials.

The human-computer interactive behavior is effected by interfaces on computer monitors, physical settings, and social context of learning environment. Users have a variety of responses to computer interfaces, e.g., reflective, thoughtful, and changing. Many factors will influence interactive behaviors, such as interfaces and individual differences the learner bring with them to the human-computer interaction processes. Different understanding of interfaces are also likely to influence user's navigational pathways [Cantner et al. 1985], navigational patterns [McAleese 1989], and content exposure [Jih 1991]. In order to increase the learner's satisfaction and performance and to create high-quality interactive courseware, designers must take human factors within learner-courseware interaction into account with specific reference to perceptual, physiological, and psychological aspects.

**Research Design**

The design of this study included observational and correlational methods. The sample group in this study included 47 female and 52 male fifth-graders. Participants were recruited from two elementary schools at the metropolitan area of Taipei, Taiwan. Subjects ranged in age from 10 to 13yrs with a mean age of 10.92yrs.
The research material, Earth courseware, was designed and developed by the researcher in 1995. The Earth course consists of concepts on Earth rotation, Earth path, celestial sphere, and time measurement on Earth with a RPG (role playing game) treatment. The virtual character of Tou-Tou dinosaur is the mentor of learners; the monster represents the opponent; the bullets represent activity scores. The computer systems were the MPC 486 with Chinese MS Windows 3.1.

The PreCourse Questionnaire queried subjects about their personal background, previous experiences with electronic appliances and computers, and personal knowledge of windows interfaces with pretest questions. On-line data tracking was used throughout the courseware to record subjects' learning pathways through the courseware. This data was used to indicate the degree of content exposure as well as time/duration experienced by subjects in the target module. Learning Performance of Earth was measured via a paper-and-pencil Posttest.

Research Findings

1. CONTENT EXPOSURE: About one third (n=29, 29.3%) subjects completed the maximum content screens (100% content exposure) of the Earth course. Only eight subjects (8.1%) completed less than half of the content screens (50% content exposure). The average Content Exposure is 80%.

2. HYPER DEGREE OF INTERACTION: Of course, subjects may access any screen more than once. In any screen of 21 content screens in courseware, subjects might browse through it without activating any learning activity (access only) or they might react one learning activity (access and reaction) several times. The Hyper Degree of Access and Hyper Degree of Reaction were then computed as the following equations:
   • Hyper Degree of Navigation = No. of Total Navigation Screens/ No. of Content Screens
   • Hyper Degree of Reaction = No. of Reaction Screens/ No. of Content Screens
   Subjects who navigated through more than 21 content screens earned a Hyper Degree of Interaction (Hyper Degree of Navigation or Hyper Degree of Reaction) higher than 1.

3. INTERFACES OPTIONS USED: Thirty nine subjects (39.4%) never used the "Try Again" icon while four subjects (4.0%) used it to reactivate the learning activity over 5 times. Nearly half (n=47 or 47.5%) of the subjects never ask for help and guidance or replay questions while three subjects clicked icons over twenty times. Twenty nine (29.3%) subjects used the 21 hyperlink icons once to view linked screens.

4. DEGREE OF CORRECTNESS IN DISCOVERY LEARNING ACTIVITIES: Nineteen subjects (19.2%) completed all learning activities correctly. Almost one third subjects (n=30 or 30.3%) answered over seventeen (80%, mastery level of learning outcomes) activities correctly. The Degree of Correctness is then computed as No. of discovery activities/No. of Reaction Screen.

5. DEGREE OF LEARNING DURATION: Subjects spent an average of 88 minutes on the course with a maximum interaction time of 129.40 minutes and a minimum interaction time of 32.45 minutes. The Duration Degree of Navigation and Duration Degree of Reaction were computed as the following equations:
   • Duration Degree of Navigation = Total Navigation Time/ No. of Navigation Screens
   • Duration Degree of Reaction = Reaction Screen Time/ No. of Reaction Screens
   Subjects who stayed longer in each content screen (reaction screen) earned a higher Duration Degree of Navigation (Reaction).

6. LEARNING PERFORMANCE: Forty subjects (44.4%) earned a score higher than the mean score of 8.20. The highest test score was 14 by one subject in the possible range of 0 to 18. Three subject had the lowest score of 3 correct answers.

Hypotheses Testing

For RH1, the null hypotheses was that learners' field independence, their previous experiences with technology, their familiarity of Windows interfaces, and their level of prior content knowledge are not related with the number of screens seen and interaction time in guided-discovery hypermedia courseware with a RPG treatment. This hypothesis was based upon the mastery learning that more experienced learners with better prior knowledge would view more the course content and use more options. The results indicated that a significant negative relationship exists between subjects' game and maximum technology experiences and subjects' duration of navigation as well as
duration of reaction. The subjects' interface familiarity revealed a negative relationship between the subjects' duration of reaction. The null hypotheses is rejected at the .01 level [Tab. 1].

For RH2, the null hypotheses was that the scores of prior knowledge, the numbers of screens seen and interaction time by learners are not related to their performance scores. It was hypothesized that the more screens they viewed, and the more options they used, the higher their performance score would be. The null hypotheses can be rejected since the correlation of r=.3495 for science grade scores and r=.2886 for pretest scores and performance scores was significant at the .01 level [Tab. 2]. The results indicate that a significant positive relationship exists between the subjects' prior domain knowledge and subjects' learning performance.

For RH3, the null hypotheses was that learners' performance scores cannot be predicted by selected individual differences, interaction time, and content exposure. Following the Mastery Learning theory, not surprisingly, the subjects with better prerequisite domain knowledge tended to earn higher performance scores. The Science Grade scores became a significant predictor of performance scores as other variables were deleted at the .01 probability level with a standard coefficient (beta) value of .9710 [Tab. 3].

Table 1: Correlation Coefficients Among Subjects' Previous Technology Experiences, Interface Familiarity, and Science Grade Scores and Their Interaction Time

<table>
<thead>
<tr>
<th>Interaction Time</th>
<th>Computer</th>
<th>Elec</th>
<th>Game</th>
<th>Max.Experience</th>
<th>Interface</th>
<th>Science Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration degree of navigation</td>
<td>-.1549</td>
<td>.0077</td>
<td>-.2942*</td>
<td>-.2748*</td>
<td>-.4121</td>
<td>-.1570</td>
</tr>
<tr>
<td>(1.26)</td>
<td>(.939)</td>
<td>(.003)</td>
<td>(.006)</td>
<td>(.000)</td>
<td>(.121)</td>
<td></td>
</tr>
<tr>
<td>Duration degree of reaction</td>
<td>-.1487</td>
<td>.0349</td>
<td>-.2948*</td>
<td>-.2634</td>
<td>-.3517*</td>
<td>-.1680</td>
</tr>
<tr>
<td>(.142)</td>
<td>(.731)</td>
<td>(.003)</td>
<td>(.008)</td>
<td>(.000)</td>
<td>(.096)</td>
<td></td>
</tr>
</tbody>
</table>

Note. n=99. *p<.01. The critical r value at df=90 was .2670 at the .01 level. The probability appears in parentheses.

Table 2: Correlation Coefficients Among Subjects' Performance Scores and Their Prior Knowledge Scores

<table>
<thead>
<tr>
<th>Performance Scores</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science grade scores</td>
<td>.3495*</td>
<td>.000</td>
</tr>
<tr>
<td>Pretest scores</td>
<td>.2866*</td>
<td>.000</td>
</tr>
</tbody>
</table>

Table 3: Summary Table of Multiple Regression Equations

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient(B)</th>
<th>S.E</th>
<th>StdCoeff.(Beta)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Grade Score</td>
<td>.095535</td>
<td>.002376</td>
<td>.971010</td>
<td>40.213*</td>
<td>.0000</td>
</tr>
</tbody>
</table>

Implications

1. Courseware for learners who has previous knowledge of and experience with the multimedia/ hypermedia needs more features to attract learners' attention on interaction/learning time.
2. Guided discovery learning methods in RPG media is a successful CAL design for science instruction to allure learner's active participation in self-learning processes.
3. Any good courseware with proper scenario design, sufficient activities, and user-friendly interfaces would minimize the amount of cognitive load dedicated to understanding how to use the courseware and maximize the amount of cognitive load that can be dedicated to the content of the course.
4. The Role-Playing-Game treatment is suitable for both field-dependent and field-independent learners with a guided discovery scenario.

Recommendations For Further Studies

1. A study replicating this effort with larger sample sizes should be conducted.
2. Other variables of individual differences should be examined such as learning needs or goals, computer experience other than the instrument type, and learners' self-esteem with respect to their computer literacy.
3. More data resources of users interactive behaviors collected by a variety of approaches should be explored, e.g., observing learners learning to navigate through a courseware, asking learners to explain the courseware to a new learner as the co-experimenter, and/or observing the learners and co-experimenter navigating through other sections of the courseware or another similar course via verbal protocol, questionnaires, interviews, and on-line computer coding. Such research could yield the patterns of their content exposure, and other factors possibly existing in the human-computer interactions.

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References
Delivery Methods for Hypertext-based Courseware on the World-Wide-Web

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Abstract: The World Wide Web Initiative has provided a means for providing hypertext and multimedia based information across the whole Internet. Many applications have been developed on such http servers.

One important and novel development to the server has been the development of courseware facilities. This ranges from the provision of on-line lecture notes, exercises and their solutions to more interactive teaching packages. A variety of disciplines have benefitted notably C programming, X Windows, Computer Vision, Image Processing, Computer Graphics, Artificial Intelligence and Parallel Computing. This ranges from the provision of on-line lecture notes, exercises and their solutions to more interactive packages suited primarily for teaching and demonstration packages.

This paper will address the issues of (i) implementing of a variety of computer science courses and (ii) using the packages in a class environment.

The paper addresses issues of how best to provide information in such a hypertext based system and how interactive image processing packages can be developed. A suite of multimedia based tools have been developed to facilitate such systems and these will be described in the paper. In particular we have developed a number of methods for running applications live over the WWW.

Introduction

The use of computers to provided an integrated environment for teaching a variety of disciplines has received much attention in recent years. Indeed many frameworks have been developed for such purposes. The material provided by such courseware varies greatly from the provision of lecture notes and lecture support material through to integrated and interactive tutorial packages. Until recently courseware has existed as stand alone packages, however with the advent of the World Wide Web (WWW) on the Internet and accompanying WWW (hypertext) browsers, such as Netscape and HotJava, the provision of courseware has taken on a whole new dimension.

Many subjects can benefit from the provision of such courseware. Indeed we are probably fortunate that our chosen disciplines lend themselves to such methods. For example many methods that we describe in our courses are interactive and can take on many states depending on the input data. It is difficult and/or time consuming to convey all such possibilities in a lecture (or on static text such as handouts or textbooks). Integrated courseware has any obvious advantage in presenting such material.

In this paper we present our experiences of implementing courseware to support the teaching of six courses: C programming, X Windows, Parallel Processing, Computer Vision and Image Processing, Artificial Intelligence and Computer Graphics.

Developing Courseware

In this section we aim to summarise our approach to developing courseware on the WWW. We begin by highlighting the advantages of using the WWW for courseware. We then broadly describe how the work has been implemented.

Developing courseware is not merely a matter of preparing a series of lectures, linking them together and packaging them as a course. A comprehensive design strategy must also consider how to implement and manage a course, how to evaluate the materials that are used, and how to assess the learners. Therefore a systematic approach to the development of course materials. According to Rowntree [Row82] the systems approach should incorporate four basic strands: (a) Identify course aims and objectives; (b) Develop necessary learning experiences; (c) Evaluate the effectiveness of learning experiences; and (d) Improve the experiences in the light of evaluation.

In the remainder of the paper, each of these four strands will be addressed.

Identify Course Aims and Objectives
One of the initial, intended goals of our courseware was that it can be used in a variety of courses, perhaps including undergraduate degree programmes in computer science, physics, all branches of engineering, mathematics and electronics, as well as the basis of training courses run by computer service departments. The challenge of designing learning materials for such a diverse group is to make the materials approachable for all classes of user, and yet maintain a high degree of specialism, for example, relevant to the field of parallel computing or computer vision.

Designing such materials confronts many well-established and accepted instructional design principles. The first step in many instructional design models, is to analyse the learners who will use the materials. Analysis of even a subset of potential users, however, would have proved expensive and time-consuming. Therefore a compromise was made by putting effort into ensuring that the material would appeal to a broad audience.

The characteristics of an instructional medium which interacts with the learner are the tasks that might influence the learning process [Koz91]. One concern might be how the choice of hypermedia might affect learning. Advantages of hypermedia include giving the user control over the learning process. However disadvantages [Lau93] have cited the lack of feedback and guidance given.

There can be little doubt that the WWW has become the most successful networked multimedia hypertext based system in recent years. The HTML language used in WWW documents is extremely simple and yet powerful to use. These factors highly influenced our choice of hypermedia implementation systems. We believe that in the careful design of implementation we have addressed some of the critiques of multimedia, e.g. feedback is provided by parts of our courseware including the automated assessment of exercises.

However several severe restrictions in the current WWW protocol mean that more advanced hypermedia systems need developing.

The recently developed Java programming is significant here because it makes the WWW truly interactive by incorporating applications that can be programmed, run live and distributed in a simple, safe and portable manner. Java also provides an extensible method to handle, internally, new data type and protocols. Briefly, one can think of Java as a simplified, safe, and device independent version of C++.

How can this influence Courseware on the WWW?

The innovations provided by such second generation browsers provide many interesting possibilities with respect to developing courseware. Applications can now become truly interactive. Also significant advances in incorporating a full range of media have been made. Distributed hypertext linking over the WWW should also be improved.

Develop Necessary Learning Experiences

The materials originally designed at Cardiff were based on lecture notes from existing courses. The use of lecture materials is a logical foundation on which to build a course. On their own, however, lecture notes are insufficient. User activities during learning are more important in determining what is learned than the presentation of instructional material [MK93]. The aim of evaluating the original lecture notes was to convert them into more effective learning materials. To accomplish this, the initial lecture notes in HTML format were evaluated using models developed from principles of instructional theory. Evaluation was undertaken at an organisational level and instructional level. The organisational level focuses on courseware structure, by means of analysis of users and evaluation of the learning that has taken place. At the instructional level evaluation was concerned with the educational effectiveness of unit content.

Organisational Unit Design

We initially considered several Instructional Design models and eventually adopted an established instructional design model: the ASSURE Model developed by Heinich, Molinda and Russells [HMR93]:

A Analyse Learners
S State Objectives
S Select Media and Materials
U Utilise Media and Materials
R Require Learner Participation
E Evaluate and Revise

The use of the ASSURE model for initial evaluation allows for the systematic alteration of existing course material (lecture notes, etc.) by focusing on learning issues which might not have been addressed in the original lecture notes, such as the potentially diverse characteristics and experiences of users. For example, this led in many cases to the alteration of language to suit a more general audience.

Instructional Unit Design

The instructional level of evaluation is concerned with increasing the educational potential of each unit. This evaluation framework was adapted from Gagné's sequence of Instructional Events [GBW92], which are based on the hypothesised sequence of internal stages of information processing derived from studies of cognitive processes.

The use of Gagné’s events of instruction as an evaluation tool led to further changes in the development of a suitable model and particular changes in courseware content. For example instructional event three, stimulating recall of prerequisite learning, led to the insertion of additional references to other units.

Utilisation of the ASSURE model and Gagné's Instructional Events is not intended to provide a prescriptive design model. Rather, it provides a framework based on sound instructional strategies within which it is possible for individual course designers to develop a dialogue about design strategies. The tools provide a common ground for

Utilise Media and Materials

The following sections contain illustrations of two implementations of hypermedia incorporated into the courseware.

Using Mpeg Movies to Animate Algorithms

The mpeg movie format is the most popular storage format for image sequences on the WWW. Most browsers are able to support such a format. Animation of algorithms is clearly a useful learning tool [Mar95]. Illustrations can be compiled off-line and simply stored and played back on request. Our courseware has extensive use of such a facility.

Using Forms and Scripts to Achieve User Interaction

User interaction in hypermedia environments is often limited to selecting options with a mouse. In such an environment, the learner is merely presented with the information, having few opportunities to interact with the material. The HTML language however provides opportunities to develop additional types of participation. Consider the following example:

Simulated annealing is a non-trivial multiprocess whereby the loads on a processor network may be minimised (usually not optimally). Observation of students has shown that involvement in the implementation of this algorithm improves their comprehension of it. The courseware implements a simulation which allows the user to execute the algorithm on a simple linear processor network. The user is able to see the results of the algorithm by means of a graph which plots the load on the network against the "work" done by the algorithm. To enhance understanding the user can adjust the various parameters which affect the algorithm's performance. The algorithm can be rerun with different parameters, and the new results are plotted on the same graph with the previous results. This allows the user to compare and contrast performances, and understand how the parameters affect the algorithm, and consequently more fully understand how the algorithm works.

The demonstration of simulated annealing is possible because HTML allows links to executable programs and scripts. As long as a suitable HTML document is produced by the program(s) called, the user is unaware of all the "behind-the-scenes" operations that are taking place.

The main feature of HTML which allows user interaction is the HTML form, which enables user input to be passed to the programs which produce the HTML documents. A snapshot of a form based interface example is shown in Fig.1.
We have also made extensive use of forms and scripts to provide comprehensive search facilities within our courses. This is a popular tool since it provides an easy means to access parts of the course in a similar manner to the index of a book.

Using Java for true algorithm animation and user interaction

The recent innovations provide by the Java language and its ability to integrate runnable applications live over the WWW provide many exciting possibilities.

The first version of the courseware [Mar94] was implemented before the advent of HotJava. All the background processing performed in the initial versions live was achieved by running (Perl) scripts and C programs with the resulting data and images mapped back to the HTML browser (Section 4.3.2). The second version of some of the courseware has the processing routines rewritten, where appropriate, in HotJava. This was not a major problem as the routines were available in C and easily modified for the (C++ lookalike) Java language. Examples of the courseware featuring HotJava applications (applets) for thresholding of an image are illustrated in Fig.2.
Overview of Current Implementations

The courseware we have implemented currently integrates the following:

- Course notes, program listings, reading lists, class information etc.
- Algorithm animations e.g. interactive image processing over the WWW.
- Links to run programs and view program output.
- Exercises and solutions.
- Links to other sources of information on the WWW.

The courseware follows the basic framework laid out above in that major topics are basically treated as chapters of a hypertext book. Sub-topics are sections and subsections of each chapter. Many examples of results are given in the form of image sequences. These are simply hypertext links to images. One other development is that live data processing can be performed on the WWW. This has been achieved by spawning programs, Java applets or scripts in manners described previously.

Conclusions

From the experience gained from using a variety of browsers and the WWW to develop a variety of courses in a number
of situations we conclude the following:

- The courseware packages were easy to develop.
- Students find the packages easy and intuitive to use, in particular:
  - They can work at their own pace.
  - The environment allows a two-way learning process.
- The courseware is very popular with students and increasingly to a wider audience over the WWW.
- The courseware are easily extensible and updatable. Material from the whole WWW can be easily integrated. The ability to use Unix (and other) scripts and more significantly to run (Java) programs directly means that little is not achievable with careful thought and planning.
- Our courseware has been recognised as a beneficial aid to learning.

References


Experience with the Learning Web

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Abstract: The learning web approach can be introduced into existing undergraduate courses and doing so provides the basis for its implementation on a larger scale transcending institutional boundaries. However, an essential prerequisite is the restructuring of existing pedagogical approaches, de-emphasizing received wisdom and authority of the instructor, and emphasizing collaborative learning and meta-reflection on all aspects of the learning process itself. The instructor becomes a facilitator of students learning to learn, and eventually that process of learning to learn must itself become an overt topic for discussion by students fully participating in its management. In the same way that in the current educational system the home prepares for the school and the school prepares for the university, the university must come to see itself as preparing students for a role in a learning society in which they have come to understand and manage their own processes of lifelong learning. This article describes experience in using the learning web approach and technologies in some senior undergraduate courses in Computer Science.

1 Introduction

The learning web approach [Norrie and Gaines, 1995] offers the opportunity to restructure higher education to function through distributed communities that transcend conventional institutional, regional and national boundaries. However, the methodologies and technologies involved may be applied on a smaller scale to existing courses in order to facilitate collaborative and self-directed learning and break out of the traditional lecture and classroom format. This evolution based on existing courses is important because it provides the resources and experience to develop the learning web on a larger scale. Transforming an existing course to operate as a learning web not only facilitates coping with larger and more heterogeneous classes locally, but also makes the learning materials widely available for use elsewhere. Initially, institutions may share learning web course material as they 'share' textbooks, each using it independently within their local courses. However, the ethos of the learning web approach is such that it will be very natural to merge courses across institutions until eventually the notion of a course at an institution itself becomes meaningless.

Our initial aspirations for learning web applications are modest in comparison with the wider vision of what is possible in the long term. However, the seeds of large scale implementation are present in the early applications. Already materials that have been developed for local use have been accessed across the web by teachers and students in more than 25 countries, and learning web tools are being used by others world-wide to facilitate learning in a range of applications wider than we have imagined. The Internet provides an environment where the seeds propagate rapidly, and 'collaboration' occurs between groups who know very little of one another.

2 The Learning Web Approach to Computer Science Teaching

This article describes how the learning web approach and tools are being used in two senior undergraduate courses in Computer Science. The students have access to excellent computing facilities and are familiar with the use of computer-based tools, so these experiments do not address issues of access or literacy. The students should have no problems with the technology and, if they do so, it is the technology which is problematic.

However, computer science teaching generally follows the traditional view of 'privileged knowledge' in which it is the business of the professor to impart the knowledge embedded in texts. Students are fed 'knowledge' in measured portions, expected to digest it, and give evidence in the form of assignments and examinations that they have done so. The 'received wisdom' approach emphasizes individual learning and provides little experience in collaborative activities. This is singularly inappropriate to the post-modern employment environment of computer scientists. They need to become reflective practitioners in Schön's [1983] terminology, because they will need to continually adapt throughout their careers to social change in which their discipline plays a major role. Thus, our experiments have been directed towards using the learning web approach to facilitate collaborative learning in a community of students for whom it is not natural through past experience, and yet where employers expect graduates to function effectively within teams and organizations.
The received wisdom approach is inappropriate to the post-modern world which is characterized by rapid change rather than the application of well-established knowledge. A more operational view of knowledge takes a constructivist approach to learning which is exemplified by the work of Piaget [1972], Papert [1980] and others. This theory of knowledge implies that students learn through active involvement in the social processes of the construction of meaning. Understanding is based on active participation in the subject matter and reflection on conversations with others on the topics of a course. This is the Schön’s "reflection-in-action" in which research and learning is a joint enterprise, and leads to a less authoritarian model of professionalism.

As Sculley [1991] has emphasized, the key strength of 21st century organizations will be their ability to unleash and coordinate the creative contributions of many individuals; over-specialization and a limited perspective can be a dead-end trap; individuals will need to have the flexibility to move around; diverse educational experience will be the critical foundation for success; what we will need is not just mastery of subject matter but mastery of learning; we must have access to the unbounded world of knowledge; we must create a learning environment in which research and instruction are integrated. He specifies the requirements for lifelong learning:

- It should require rigorous mastery of subject matter.
- It should hone the conceptual skills that extract meaning from data.
- It should promote a healthy skepticism that tests reality against multiple points of view.
- It should nourish individual creativity and encourage exploration.
- It should support collaboration.
- It should reward clear communication.
- It should provoke a journey of discovery.
- It should be energized by the opportunity to contribute to the total of what we know and what we can do.

These have been the goals of restructuring some Computer Science courses using the learning web approach.

3 Software Engineering

Software engineering is an excellent topic within which to introduce social perspectives because it has long been widely accepted that the problems of harnessing the talents of individual programmers into collaborative teams is a major one for the computer industry [Brooks, 1975; Mayrhauser, 1990]. In recent years the gap between customer and user requirements and computing system specification has also become of major concern—requirements engineering is now a major sub-discipline in its own right [RE, 1993; Shaw and Gaines, 1994]. Thus, it is natural to introduce psychological and social issues in a software engineering course, and to design project work that gives students personal experience of social phenomena in overt and discussible form.

The curriculum developed for CPSC 451, a required software engineering course for all Computer Science majors at this University, is centered on projects that involve the students playing roles in teams representing customer and supplier organizations. There is a lecture component of 3 hours a week for 13 weeks, and a laboratory (practical) component of 3 hours a week for 13 weeks. The lectures are of standard format covering classical software engineering topics and methodologies, including the SEI levels of maturity and continuous improvement in an organization [Humphrey, 1989].

Each student is assigned to two different groups of 10 to 12 students. In one group she is one of the supplier team, and in the other one of the customer team. The students are assigned based on a number of factors such as: having taken the human-computer interface course, having taken a theory course, and length of time in the program, to try to make each group as varied as possible but at the same time as similar as possible to the other groups. The total class size in the past has been around 50 to 60 students, but in recent years has increased to 120 to 150 due to financial constraints.

The process starts in the last 5 minutes of the very first class, when each customer group is allocated a project at random. The course web site gives a very short, informal and vague description of the problem. For example:

Write a specification for a system linking supermarkets to a grocery supplier to process the ordering from one end and the invoicing from the other. Both sides should have strategies e.g. reorder when the stock drops to a certain level; do not invoice until the stock has been received. This requires the minimum data entry, but complete security.

Each group gets a different problem, but they are all of a similar level of complexity. Each customer group has two days to prepare an informal requirements document for the project and post it on the web. They are subsequently responsible
for its evaluation and criticism as it progresses; that is, they are the customer for the system. They are expected to be present at all presentations to ask questions, and comment on all the write-ups and documentation. Each grade, given by the instructor not by the students, depends on how thoroughly the evaluation is carried out, the extent to which it is fair and reasonable and the extent with which it agrees with a well-founded methodology. Groups are advised to show all drafts to the teaching assistant (TA), and discuss any problems or disagreements. It is not very long after the start of the project that the customer and supplier groups reach the conclusion that the interchange cannot be done entirely by web-based documents, and that they need to meet and negotiate problems, expectations, and what will be included in each version of the software.

The supplier group works for the customer group, receiving informal requirements for a system, annotating the requirements on the web with queries and suggestions, producing a formal specification, a management plan, the analysis and design in the form of an overall and a detailed design document including test plans, a user manual, coding a prototype, evaluating and refining it, and presenting a final (prototype) product according to the details given. Public (to the whole class) oral presentations and discussions are required at various points within the project, and are evaluated and assessed by the customers. It is certainly not required, but often the students will arrive in their best business clothes for the presentations, and fully enter into the roles they have been given. Every 3 to 5 days another part of the project becomes due for submission to the customers, and students are quickly made aware of the social pressures to conform to due dates. This may be the first time that any of them have considered that due dates are not altogether arbitrary, and that other people's deadlines depend on them. In turn, each student may be inconvenienced by other people's last minute rush to complete work, not only in the other group, but also in their own where, for example, an editor may require input from several people before a final document can be prepared.

No marks are given for coding. This is where much of the effort goes, and this practice seems to the students to be unfair. However, in this course all the students have a thorough grounding in programming, and what they are learning is the application of what they already know or is being covered in specific lectures, the management of their time, how their own working style fits into the range of working styles among their peers, and how their own time and work management affects others. Each student keeps a log of activities in the form of a diary with dates, what was done, and time spent on each item. At the end of each month, every student prepares a set of reports assessing each member of their supplier group. This requires a paragraph per person, including themselves, outlining who did what during the month, and how their work can be assessed, using some sort of grading scheme on one or more criteria. This means that they must get to know the people in their group as soon as possible, and decide how each has contributed to the group work during the month. This is not optional, but is a required part of the assessment to pass the course. In general the reports are thoughtful and responsible. The students do not always give themselves top marks, but say things like: "x did not contribute much to the group discussions -- maybe I spoke too much of the time and didn't give x a chance"; or "I thought y was really stupid at first because his section of the documentation was such a mess -- but I soon found out that he was a very good programmer and just had difficulty expressing himself in English".

In order to prepare students for the project, information is given about personality variables, the range of possible working styles, and how a person's strong points should be built on rather than concentrating on their weaknesses. Each student is profiled using a short form of the Myers-Briggs Type Indicator to find out their own preferences, and discuss how each type can benefit from input from other types. The students invariably get the message, without it being made explicit, that their job is to encourage the smooth functioning of the group and to involve every member as equally as possible without requiring everyone to take part in every job.

It is not necessary to make explicit the psychological and sociological perspectives of the academic curriculum in CPSC 451. In any event, the science curriculum to which most of the students have been exposed encourages linear thinking and objectivist values, and is a poor foundation from which to understand the life world. The students experience the significance of roles, conceptual systems and inter-personal interactions. The alternation of their own customer and supplier roles brings them to terms with the nature of conceptual systems, both their subjective artificiality and their ethical implications in terms of role consistencies, responsibilities and accountabilities. Being responsible for conceiving and articulating requirements, in particular, is a new experience for most students, and leads them to be more thoughtful about how those requirements arise.

It has been natural to introduce the learning web tools into the operation of CPSC451 as part of the customer-supplier interaction in the group projects which form a major part of the course. All the course materials are already made available to the students through the web, and it is natural for them to place the documents relating to customer requirements, supplier comments and proposed solutions, the ensuing negotiations, and descriptions and screen dumps of the developed applications on the web. The use of a list server for the discussion and negotiations means that the process of constructing a specification is automatically documented and the archives are available on the web. Repertory
grid tools are already in use in requirements engineering for the elicitation of the critical dimensions of an application from customer, user and implementer perspectives, and concept maps are in use as diagramming tools for computer-aided software engineering.

Thus, none of the current learning web technologies is seen as being a radical departure from normal practice once the students have adopted their roles within the customer-supplier teams. In CPSC451 the tools are used to encourage reflection directed to the processes of software engineering, and not to the processes of learning about software engineering. This is done in a senior course for which CPSC451 is a prerequisite which is usually taken one year later as described in the following section.

4 Advanced Information Systems

Advanced information systems provide a topic where social perspectives are readily seen to be essential to redress technological bias. In developing the curriculum for CPSC 547, an optional course on advanced information systems for Computer Science majors, it was known that the final year students already had theoretical foundations for technologies such as object-oriented programming and databases. In addition, many of the students who were attracted to this course also had substantial industrial experience. For example, they understood object-oriented technology in terms of type theory, modularity, and so on, and they understood that it was having a major impact on industry, but they had few sources available on how to bridge the gap between theory and practice: for example, to be able to see object-oriented databases as providing a more effective enterprise modeling technology than relational databases; from there, to go on to the questions of the interplay between organizational needs and technological capabilities; from there, to go on to the question of the influence of the technology on organizational design; and so on.

However, the agenda for CPSC 547 goes far beyond these simple techno-social considerations. The students in this course are preparing for a new industrial infrastructure which is itself radically different from that of a few years ago. It is 'post-modern' in the sense of Ekins and Max-Neef's [1992] real life economics recognizing the plurality of economic sectors including environmental and domestic capital, of Warnecke's [1993] fractal company designed to encourage the growth of complete and robust sub-organizations self-similar in their functionality to the whole, of Wheatley's [1993] emergent organizations recognizing the adaptability of the creative chaos of the life world. In Calgary, the recession has seen the end of the large-scale information systems divisions of the oil majors that has dominated computer science employment opportunities in Alberta. Hundreds of information systems professionals have already had to come to terms with a new industrial environment that emphasizes small, adaptable, entrepreneurial organizations. Our graduating students need skills that go beyond mere technical proficiency to cope with the new challenges and opportunities.

The design of an environment for reflective learning has been influenced by the recommendations and beliefs of Carl Rogers [1961] for generating a positive atmosphere in which students exhibit mature everyday behavior, are less defensive, more adaptive, and more able to meet situations creatively. This involves treating each student as an individual, being available to discuss problems individually and help with students' decision-making, creating a supportive and empathic class atmosphere in which each student is given positive encouragement to discuss issues of concern, and making the instructor's thoughts and views genuinely available for discussion. According to Rogers this allows each student to experience and understand aspects of her/himself which may not have been previously available, to become more integrated and more able to function effectively, to be more self-directing and self-confident, to become more self-expressive, to be more understanding and accepting of others, to be able to cope with new problems more adequately and more comfortably.

However, it is not simple to switch to this type of classroom interaction for those with years of experience with a traditional approach to learning. For one thing, it threatens the view of the "authority" of the professional who is the ultimate source of all knowledge, and hence requires a high degree of competence and understanding of the subject matter and its ramifications. It also involves a personal commitment to knowing every student in a class of 50 by name by the end of the second week of the course, and being willing to support requirements for resources and equipment that cannot be planned. The students do a great deal of reading the literature, thinking and discussing issues. Emphasis is on cooperation, mutual acceptance and support for differing points of view. After a few lectures, the students in CPSC 547 take over the course and run it through their own group research, presentations and demonstrations addressing major issues in advanced information systems. The students work extremely hard, are incredibly motivated and enthusiastic, achieve a very high standard of work, and think deeply not only about the technology but also about the social and ethical implications of its applications.

In CPSC 451 they learn experientially from playing the relatively well-defined roles of customers and suppliers. In
CPSC 547 they learn both experientially and intellectually from playing the open-ended roles of being researchers and educators in their own right. Each presentation tends to set a new standard of excellence which those in the later groups are determined to transcend, and find they must cooperate strongly to do so. Whereas CPSC 451 is a compulsory course, CPSC 547 is optional, and the fact that it has been one of the most heavily subscribed of our 500-level courses attests to its perceived value by students. It provides a bridge from their roles as students to their roles as industrialists, managers, researchers, members of, and contributors to, our rapidly changing post-modern age and information society.

The learning web tools are used in CPSC547 to support the conceptualization, requirements analysis, and presentation for the small group projects which are, however, broader than those of CPSC451 in that they involve the analysis of major areas of computer technology and its impact rather than the development of specific systems. Each group develops its own web site with a view to its being available to others both within the course and, internationally, across the web. They search for, and link to, relevant materials on the web, much of which now comes from other students in related courses or undertaking graduate work at other institutions. Thus, the notion of collaboration is already broadened to transcend institutional boundaries. In the preparation for the Winter 1996 course, for the first time, it has been possible to drop the circulation of reprints of published papers as course materials because adequate background materials for all course topics are now available on the web. This generation of students is already taking electronic, open publication as the norm and only using paper-based materials as a last resort.

However, the most important transition in CPSC547 is that the learning web tools are used also to encourage meta-reflection about the course and the nature of the learning experiences involved. The agenda for the course outlined above is made explicit to the students at the beginning of the course--they become owners of the course at every level from day one. The web of previous student projects and commentaries is available to them so that there is collaboration not only within the course but across instances of it, a sense of a continuing learning community where their contributions will be valued by the next generation of students.

The repertory grid tools are used to construe the course topics, and the instructors' grids are made available using the facility of WebGrid [Shaw and Gaines, 1995] to compare grids and present a graphical analysis of similarities and differences in construction. Figure 1 shows a student's grid being compared with that of an instructor. However, the grids of other students are also available so that the instructors' views have no especial priority, and the primary focus is on the discussions generated among students when they find that they have widely different constructs for what appear to be well-defined topics or are using well-established terminologies in very different ways.

5 Conclusions

This article has described our experience in introducing the learning web approach into existing undergraduate courses, including the restructuring of existing pedagogical approaches, de-emphasizing received wisdom and authority of the instructor, and emphasizing collaborative learning and meta-reflection on the learning process. Once the fundamental
Restructuring has taken place, technology can be used to provide effective support for the learning web objectives on the scale needed which goes beyond the capabilities of individual instructors. We are already seeing evidence of the positive feedback processes that are the basis of major innovations in the way that our students are using resources provided by other students world-wide and are increasingly seeing themselves as contributing to those resources rather than merely 'taking a course.' It is only a matter of time before 'guest students' from other universities are attracted to become contributors to what were initially list servers for a local course. It is only a matter of time before students graduating and taking up employment return electronically to use the list server associated with a course, either because they have come across an interesting idea or technology to contribute, or because they wish to raise a question that might be answered within the class. We have found that just making the learning web tools available on the Internet and linking them to brief descriptions on our home pages has already led to substantial world-wide use. The learning web, like the Internet and the World-Wide Web where it is now implemented, is a self-propagating culture, each use of which and each extension of which generates new uses and extensions. It has already gone beyond our capabilities to predict or control, and we are only contributors to an inexorable process of change in the structure of learning processes and institutions in our society.

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URL's for Materials


References


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Advanced Collaborative Educational Environment using Virtual Shared Space

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Abstract: This paper describes a new concept and implementation of a multi-user cooperative tele-educational environment. In this environment, a learner can get into a virtual space consisting of three-dimensional computer graphics (3D-CG), manipulate virtual objects, and have conversations with other learners in real time. The first prototype system has been developed as a server/client architecture using TCP/IP. A sample learning materials which consists of two classrooms is developed. We are currently developing the next version, which will enable learners to define new objects and their methods in virtual space and to handle objects more collaboratively.

Introduction

Computer Assisted Instruction (CAI) has been studied since the mid 1950's, and many systems are currently being used in practical educational fields (e.g. CAIRNEY [Fukuhara et al., 1991]). Most of them are based on system-driven design, in which the system leads the learner on a pre-defined path. Such systems are mainly used for self-study.

On the other hand, some studies have analyzed the knowledge acquisition process of human. Schank and Otsuki pointed out that a cycle of "trial-and-error discovery" plays a very important role in knowledge acquisition and so an interactive user-driven architecture should be developed with this in mind [Schank, 1994, Otsuki et al., 1991]. Okamoto analyzed the interaction between learners in a group-type learning situation, and emphasized the importance of interaction such as discussion, collaboration, and competition between learners. He insisted that such interaction promotes efficiency in their understanding and confirmation [Okamoto, 1994]. Unfortunately, these educational environments are difficult to implement, using traditional CAI system architecture.

Due to rapid improvements in multimedia technologies, however, user-driven and multi-user-type CAI system is becoming feasible. In the following sections, we propose a new concept of a networked multi-user and user-driven learning environment using 3D-CG and Virtual Reality (VR) technologies. We call it HyCLASS (Hyper-Collaborative Learning Application in Shared Space), and we describe the implementation of the first prototype.

HyCLASS Overview

We presented the concept of user-oriented, multimedia, and multi-user telecommunication environment; MediaWonderland (MW) [Kakuta et al., 1995]. HyCLASS is an educational application which is derived from MW. HyCLASS is based on 3D-CG and real-time conversation (including audio and video) between multi-users. Users can interact with objects and learn about the topic of the learning material.

From the users' viewpoint, HyCLASS seems to be a kind of VR application where users can walk through 3D worlds, touch objects, and communicate with other users. Users can share the space they work in. They can effectively learn together about manipulation and spatial knowledge by taking advantage of this shared environment, even when they are located separately in the real world.

On the other hand, HyCLASS could be seen as an advanced text-based conference tool, like so-called MUD (Multi-User Dungeon) or MOO (Multi-user Object-Oriented). These applications also consist of servers and clients. Unlike MUD or MOO, clients of HyCLASS can change the connection from one server to another to reach the desired service. Every client who is connected to the same server and the same room will receive the same control code for navigating the graphical and stored/real-time acoustic/visual data. When they chat with others, voice/video data will be carried through
the network with IP-multicast protocol.

Virtual world

"Room" is used as a metaphor, so that users feel as if they are walking through a real room. The virtual world may consist of multiple rooms. A room server provides one or more rooms. Each room has objects that have attributes, such as graphic data, acoustic data, etc. Users can interact with these objects as well as other users. Users are represented by 3D-CG and are called "playing characters" in HyCLASS. They can understand where others are and which directions they look to. Every object is written in object-oriented scripting language. Therefore it's easy for users to construct new objects using existing object classes and instances.

Every user in the same room can look at the same learning materials, and recognize the change of the room simultaneously, such as the position of objects. Users can walk around the room freely, so they have different viewpoints of the learning materials.

Interactions

As same as MOO, users can create new objects and learning materials easily using an object-oriented programming language. An editing and authoring tool (EAT) will be provided for users so they don't have to edit the script directly. Users can appreciate the benefit of object-oriented programming languages by reusing objects that were made previously. Users can use a class object library and construct new materials.

Users can interact with objects and other users. They see 3D objects and can manipulate them. For example, they move 3D object, rotate, enlarge, and color etc. They also create new objects using on-line EAT. They can select appropriate 3D object and attach behaviors to it from the pre-defined objects and behaviors. A behavior is written in the scripting language. It makes an object move, rotate, and make sounds automatically. When a user interacts with the method (behavior) of an object, the appropriate script is distributed through the server to all clients. The client terminals receive the script from the server, the interpreter recognizes it, and the screen is updated accordingly.

They can hear sounds from the objects or the voice of other users. They can talk together and decide what objects they should manipulate in an educational application.

In a distributed system like HyCLASS, it is very efficient to provide intelligent-agent-type search protocols when users try to find data. Agents actively understand user demands, and search by themselves. This function should be implemented for the convenience of users.

Applications

Users have their own viewpoint dependent on their position and orientation in the shared space, and they can virtually make experiments which are difficult to do in the real world. Users which are located in the distance can make a group-type learning using this system. It's expected that students acquire knowledge while they are playing and they actively interact with other students or learning materials. So this environment is advantageous for many educational fields:

Science education for elementary or high school students: Physical simulation, Astronomy.
Artistic education: Group painting or clay, Architecture.
Medical school: Simulating operation, Molecular design.
Company training: Machine maintenance or operation.

Prototype system

Overview

The prototype system consists of four clients and two servers. They are connected via Local Area Network (LAN). In our sample application, there is one room at each server. Four users can be connected to one server and share the room simultaneously. Each user is represented by a playing character and each has its own sound of footsteps.
The software architecture of the prototype system is shown below. (Figure 1) The client system has four parts: script interpreter, user interface library, voice conference library, and visualization toolkit.

The script interpreter is based on Python [Rossum, 1991], an object-oriented programming language, because it is very flexible for adding and changing objects and very effective at maintaining consistency via the network. Python is extensible: Add new commands written in Python script itself and directly from C or C++. Multi-inheritance is a specific characteristic of Python, too. The user interface is based on XForms [Overmars, 1993], which is very useful for prototyping. The voice conference tool is based on NEVOT [Schulzrinne, 1995] which uses IP-multicast protocol. The 3D visualization tool is based on WorldToolKit (WTK) [Sense8, 1993], which is a library of C or C++ and can control several types of input/output devices.

User interface

There are two types of graphical user interface (GUI) in this prototype.

One is view control and the other is method operation. Users can control their own view, such as go ahead, go back, move right, move left, turn right, turn left, look up, and look down when they click a corresponding icon with a mouse or use a joystick. We have set some variables. For example, the amount of movement was decided according to trial-and-error, in a word, experience. Users cannot control their viewpoint easily without limitations because the degree of freedom would be too much. So we restricted user operation of the view control.

The other is method operation. When a user touches an object, a pop-up menu appears. After the selection of a method on the menu, the script for this method is spread to all clients in the same room via the server. The script is executed on each client.

Sound

In HyCLASS, there are two types of sound: One is stored sound, such as the sound of footsteps; The other is real-time sound, such as voice. Each object has its own sound. For example, each playing character has its own sound of footsteps, and a box has the sound of opening and closing. When a user opens a box, the control code (script) for opening the box is sent to the server, and the server delivers it to all clients in the same room. The clients receive the control code for opening the box and the sound manager in each client generates the sound of the box opening. Real-time sound is carried through the network using IP-multicast. Users can control whether they listen to each user or not. They can stop listening to the other client intentionally. Both types of sound are monaural and they are mixed at each client terminal in real-time.
Sample application

This learning material is aimed at upper-grade elementary school students. There are four users together in the same virtual room. Three students are learning together. One teacher is supervising. They can walk around and look at or touch things.

The first room is "the Sun and the Earth". When a user gets into this room and touches the question box, the box says "In which season are the views of the sun the same in the Arctic and in the Antarctic?" When student A goes to the Arctic and student B goes to the Antarctic, they can look at the views from each position of the earth. And they can move the earth to change the seasons. Student C look at the sun, the earth, and other students on the earth. They can talk about the views and the relation between the sun and the earth. Finally they all understand the relation between the sun and the earth. (Figure 2, 3, 4)

The second room is the "Expanded Figure". The question box says "Which object is the same as the expanded figure?" The user can expand or fold the objects using a pop-up menu interface and look at them from every direction. They can understand the correct object during the trial-and-error. (Figure 5)

These two rooms are connected with doors. A user can go to the other room only with pushing a door.

Discussion and Future work

Evaluation

We evaluated HyCLASS in the sample application as described in 3.4, to investigate its potential and limitations. Its suitability for applications such as Astronomy or Geometry was revealed. For example, we could view the sun from the Arctic, where we cannot easily go. However, the sensation of sharing virtual space and communicating with each other in a virtual world was somehow strange, compared to the real world.
Considering total performance, the 3D-CG rendering speed is not sufficient because of limitations in graphics processing and audio data handling. When we were creating the sample application, it was a little difficult to write the scripts for objects from nothing. EAT must be developed to reduce user effort when making objects. This EAT will provide easy operation, using inheritance and object search to the maximum.

Considering the user interface, we limited the user's viewpoint control, but this still proved to be difficult, although it was better than control without limitation. We must investigate the best view-control method. We hope that the active user interface will help users. For example, the system provides semi-automatic navigation. When a users select a method, "Move around", he can move around the object automatically. We found there is some difficulty during method selection using text letters on the menu. We plan to use graphical icons and investigate what the best selecting method is, including what the best input device is.

As regards sound, it plays an important role in the virtual world as well as in the real world. The user can appreciate the existence of other users, hearing the sound of footsteps or a door opening out of view. We implemented monaural sound because it required less computation. We plan to try stereo 3D sound, which simulates the natural sound quality of the virtual world. We also need 3D real-time voice because of the natural implication of the user's location. Many methods of creating 3D sound have been proposed [Begault, 1994]. We intend to evaluate them and choose the best one.

This sample application is a small world with simple graphical objects, and it could be more realistic. To establish a virtual laboratory, for example, real-time simulation is necessary. This will become apparent after we have solved interference and collision detection problems. Finally, we will need a field trial and evaluations from real users, such as real teachers and students.

Related systems

Charles Rich et al. presented an Interactive Multimedia Environment [Rich et al., 1994]. It has artificial agents, but does not have selective interactions with objects. It does not carry sound data without an analog line.

DIVE - a platform for multi-users virtual environments [Carlsson and Hagsand, 1993] that have selective interactions with objects using Tcl/Tk and sound transmission using NEVOT. It is very similar to our system, but it doesn't focus on the interactive object manipulation for educational fields.

The standardizing process of VRML 2.0 [VRML, 1996] is going on now. VRML is originally 3D modeling definition for World-Wide Web (WWW), however behaviors of objects, and multi-user related functions will be added. There are several proposals for VRML 2.0, and final draft will be made by this July. We are watching this activity closely.

Future HyCLASS

We intend to improve and refine HyCLASS according to the above evaluation. We add new features. For example, real-time Editing and Authoring Tool. We'll use distributed object technology, because users and even system designers don't care about where appropriate objects are. We'll use CORBA (Common Object Request Broker Architecture) products in place of the usual client-server architecture. It is difficult to read texts in only 3D worlds and teaching mechanism is needed for learning complex matters. So HyCLASS will need the function of reading text easily and such a teaching mechanism We are considering of choosing CALAT [Nakabayashi et al., 1995], which is WWW based CAI system. In addition HyCLASS will support VRML2.0 and contribute to future VRML standardization.

Conclusion

We have proposed a new idea for a cooperative networked educational environment. We have developed the first prototype system and shown a simple application for multi-user education. We have discussed its problems and improvements. We are planning and developing the next version of HyCLASS and will evaluate it in the real field.

References


Improving WWW-Aided Instruction
A Report from Experience

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Abstract: A growing number of instructors are putting course resources on the World Wide Web (WWW) [Berners-Lee et al. 1994], from simple course descriptions through traditional printed handouts to complete “classroom-free” classes ([Team Web 1995] provides a broad sampling of such resources). However, there appears to be a paucity of evaluation of WWW-based classroom resources. Do they help or do they hurt? Which materials are more valuable or less valuable? After using a wide range of resources — including readings, notes, transcriptions, and traditional handouts — in two introductory Computer Science courses for nonscientists, I surveyed students about their reactions to the materials. Based on the reactions of the first group of students (Summer 1994), I redeveloped the collection, organization, and survey form. This paper reports on the redevelopment of the course web and the subsequent student reactions for the Summer 1995 session.

Introduction

Hypermedia is beginning to change the way we think and teach. While sophisticated hypermedia applications, such as Perseus [Marchionini and Crane 1994] [Crane 1995] provide the promise of new learning and teaching strategies, a simpler and quieter hypermedia teaching revolution is upon us: the use of the World Wide Web for providing course resources. The University of Texas at Austin World Lecture Hall [Team Web 1995] presents resources from hundreds of online courses in dozens of disciplines. In spite of the vast array of electronic courses, there seems to be little formal or informal evaluation of WWW-aided instruction, other than short notes, such as [Windley 1994].

There are a number of questions that might be asked about the design and implementation of course-based webs. These include

• What materials does the web include, and why? Some courses provide only homework assignments and a few informational handouts; others provide enough materials to support a complete “classroom-free” course, in which students can attend only through the web.

• How is the web created? Some use automatic conversion programs to convert preexisting materials; others completely redevelop materials to take advantage of the additional capabilities of hypertext.

• What is the relationship between the WWW resources and the course as a whole? Some webs simply reproduce printed handouts; some treat the WWW as a presentation medium for overheads akin to PowerPoint; still others provide additional materials that students would not otherwise receive, such as hints and collections of questions and answers. Most webs are intended only as a course supplement, although a growing number are intended as replacements for traditional classroom-based learning.

• How are the materials organized? Some webs are little more than collections of documents with a hierarchical table of contents. Others illustrate more complex relationships.

• What software supports the web? For example, is a search engine or intelligent aide included? Perhaps more importantly, questions need to be asked about the effects of course-based webs.

• What materials do students use, and why? There is little point to creating a web (or a particular component) if students do not use it.

• How do students react to the array of materials presented? Do they get “lost in hyperspace” [Nielsen 1995] or are they able to navigate sufficiently well to quickly find the materials the need. Are they overwhelmed by the materials they encounter, or are they able to select only the appropriate materials.

• Does the web of materials help students learn, or hinder learning?

• Do some use the materials as an excuse to miss lectures or discussions?
An implied reason for creating webs is that we expect reuse of materials. Do students and instructors reuse past materials? If so, how?

In a previous paper [Rebelsky 1994], I reported on the initial design and development of an extensive course web for an introductory Computer Science course and the student reactions to that web. The main conclusion of that study was that while students appreciated the effort put into the web, they felt overwhelmed by the materials, with many indicating that they deemed it necessary to print and read everything in the web (from short notes to long transcriptions of each session). Based on the student reactions to the web and my own experiences in creating it and other course webs, I redesigned the organization, content, and support mechanisms for a that web to use in a subsequent course. In this paper, I report on the strategies used for redesign and subsequent student reactions.

Background

Dartmouth's COSC004 — Concepts in Computing — is one of the new type of introductory courses designed for nonmajors that present an introduction to the field of Computer Science, rather than to only computer applications, computer concepts, or computer programming. The students in this course are generally humanists between their second and third year of college — in 1994, 25 such students participated in the course and survey; in 1995 31 such students participated. The course touches on a number of topics, including hypermedia, algorithm design and analysis, language design, theoretical Computer Science, computer programming, computer architecture, and implications of computing. Students read not only a standard textbook [Schneider and Gersting 1995], but also a number of source materials, such as [Bush 1945]. In addition, they complete a number of lengthy assignments as well as weekly laboratories and infrequent tasks. Many students also complete a course project — a significant programming exercise that incorporates key algorithms, hypermedia, information retrieval, and interface design.

The amount of material in the course makes it one of the most work-intensive courses the students encounter. In end-of-course surveys, over 90% of the students in the course regularly report that it is “much more work than the average course” (the highest ranking available in response to the question), with the remaining 10% reporting that it is “more work than the average course.” Because of the scope of material covered in the course and the workload, I chose to create a web of resources to better support student learning and accommodate some alternative learning strategies. As such, the web is intended as an aid to, and not a replacement for, classroom and assignment-based learning.

I first created such a web for the Summer 1994 session of the course. My main intent in that web was to provide as many materials as possible. Hence, in addition to including traditional materials, such as assignments and syllabus, I also included an outline of each session (prepared in advance and handed out to students at the beginning of the session), the text from the blackboard of each session (to allow students to pay attention to what was happening in lecture or discussion, rather than frantically trying to copy down every word), a transcription of each session (so that students could easily recall something mentioned in discussion or lecture), and a collection of questions and answers. I also asked each student to write a short (1–3 page) guide to a subject of that student's choosing, working under the dual assumptions that students learn by trying to teach, and that peer-written materials could better support student learning [Annis 1983]. Students could access materials through the course syllabus, through individual indices for each category of material, and from related pages. In addition, a simple WAIS-based searching engine was provided to facilitate access to materials, but students reported that they found the interface confusing, and eventually stopped using it. I had hoped to include audio and video “class reproductions” but dropped that idea because of time limitations.

Student reactions to the project were mixed. They greatly appreciated the effort I devoted to the course and found the outlines particularly useful. Many commented that they appreciated my use of outlines only as a general guide to the materials, and not a precise specification (as would be the case with an outline used to make slides). However, most felt overwhelmed by the amount of materials available. [Rebelsky 1994] presents details of reactions to both individual components and the web as a whole.

Redesigning and Rebuilding the Course Web
For the Summer 1995 session of the course, I decided to rebuild the web to take advantage of these comments and to investigate the applicability of the materials created the previous summer. Because of the exclusively positive reaction to the informal course outlines, I used those outlines as the focus of the new web. Because students invariably print such outlines, I provided them at the beginning of each session (and used a high-level outline which each outline to give them a sense of the proposed order of the topics covered that day). I dropped materials, such as transcriptions, that seemed particularly overwhelming. I also added a few types of materials that I had not used in the previous web, such as audio reproductions of the first few classes.

While the students had not reported getting lost in the web, they did report that some documents were hard to find. Hence, I continued to provide access to each document from the syllabus, from lists of particular types of documents, and from outlines of classes that used or mentioned the document. As in the prior course web, I included normal hypertext links. For example, when an assignment mentioned a topic, it also included a link to the outline of the appropriate session. Because I observed that students often skimmed through my notes, checking the high-level outline of each and then jumping to the next, I added traditional next and previous links. Although a single document containing only high-level outlines might have been an appropriate addition, I felt the syllabus provided sufficient detail for this purpose. Finally, I put the URL for each document at the top of that document, so that students could quickly find electronic copies of printed documents, and predict the name of other documents. (Some browsers, such as NetScape 2.0, now provide facilities for including URLs when printing documents, so this design decision may no longer be necessary.)

In the hopes that students would reuse past materials, I included general links to past course materials, including not only the web created for the previous course, but also the student-authored guides and selected student homework assignments. To facilitate access to these materials, I developed a simpler searching engine that, given a keyword, lists all the documents that contain the keyword along with all the lines in each document that contain the keyword. To ensure that students knew about this facility, I gave them a short assignment to use it and compare its interface to that of the traditional. I also repeated some strategies from the previous web. For example, most documents could be accessed in many ways: from the syllabus, from lists of particular types of documents, from the outlines of any days the document was used or mentioned, and with next and back links for a sequence of documents.

Finally, because students reported that they had seen little reason for HTML blackboards, I replaced those with simple Microsoft Word-based blackboards that were available on a public file server. That is, I used a computer with projector as my “blackboard”, and typed, rather than wrote. The hope in doing this was, as with the previous blackboards, to allow students to pay more attention to what was being discussed and less to trying to copy down every word I wrote.

Student Reactions

As in the prior experiment, students had generally positive reactions to the use of WWW-based resources. The reorganization and reduction in number of core materials also seemed to encourage online usage — with an average student rating of 3.3 on the question of “How often did you use the WWW-based class materials (1 = never; 5 = all the time)”? Additionally, no students responded 1 for this question, suggesting that all students used the materials at some time. Many were quite enthusiastic, with comment similar to “I hope you don't discontinue this — I think these [WWW-based materials] are a very handy reference if you need to go back and search or whatever.”

However, over half of the students still found the number of online materials and electronic handouts overwhelming. This sense of being overwhelmed may be due in part to the workload in the course. As suggested earlier, most students find that this course requires much more work than the average course. In addition, many are stunned to discover that the breadth first approach means that the touch on topics (e.g., the halting problem) that their colleagues who are Computer Science majors do not touch on until their senior year. This discovery may indirectly enhance the sense of being overwhelmed.

The revised searching engine and increased emphasis on searching seem to have paid off: 63% of the students reported that they used the new search utility. This is a significant increase over the previous course, in which
13% reported that they used the original search utility. It is likely that the reduction in number of new materials and the availability of past materials gave students further incentive to use the search feature. From informal student notes written directly on the survey, it appears that searching is not a study or retrieval technique they use regularly. Rather, it is a technique that they use occasionally, perhaps when other techniques fail.

Unfortunately, a greater percentage of students (10% in 1995 vs. 4% in 1994) reported that they used the availability of electronic course materials as an excuse to miss lectures and discussions. It is difficult to assess how much the materials contributed to these absences, as there is always a select population of students who prefer not to attend sessions. It is also pleasing to note that at least one student wanted to ensure that the web would not suffer because of the absentee students. This student reported “Those who miss class because of the WWW materials are only hurting their own knowledge, because much more goes on in class than you can get from the Web pages.”

One intent of the use of WWW resources and electronic blackboards was to change student note-taking activities so that they spent more time paying attention to ideas and topics, and less copying down whatever I wrote on the blackboard. This attempt was successful, in that 93% reported that the resources did change their note-taking habits. Unfortunately, the change was not necessarily positive. Although the overall average in response to a question on the affect of changing note-taking on learning was 3.1 (with 1 being highly negative, 3 being no change, and 5 being highly positive), 37% reported a negative effect on their learning.

There were a wide variety of opinions on the usefulness of the Microsoft Word-based electronic blackboards. While the average usefulness rating was high (3.6/5.0) and 24% of the students selected the highest possible rating, 17% of the students gave the blackboards a negative rating. Surprisingly, some students found this simple technique quite revolutionary, with one writing “I think that the blackboards were a great and innovative idea. Everyone talks about computers in the classroom — in this class, we actually got it.” Another indicated that my intent to change their habits had been successful, writing “I thought this was very handy, as it left us freer to think and talk in class.” However, there were apparent disadvantages for some students. This same student also wrote, “Maybe we (I?) became too dependent on it [the electronic blackboard], though, because many times I would go back and have no idea what they meant.” Another noted, “I learn better when I take my own notes.”

While I had hoped that students would avail themselves of materials from the previous course, most (66%) made no use of past materials. Of those that did, the primary use was to look at past student homework assignments for ideas in new homework assignments. However, 93% reported that they felt that there were general benefits to having resources from past classes available online. These results are similar to those from the previous course, in which 33% reported that they would have used resources from past classes had they been available (and another 43% said that they might take advantage of such resources, depending on needs). One student who objected to the past materials noted that they were somewhat misleading, as the course had changed from the previous session to the current session.

Discussion

The responses described above, in conjunction with responses from the past course and informal discussions with students make it possible to answer many of the questions posed at the start of this paper. What materials do students use? They seem to use almost anything that is made available. This means that they can easily be overwhelmed by the materials. They are clearly still at the stage in their learning development in which they need some guidance as to which materials to use or to avoid. Instructors can provide this guidance by reducing the number of key materials they use (particularly to short notes or outlines) and by clearly designating secondary materials. In this instance, the materials from past courses could have added to the confusion for students, but the separation of those materials should be a benefit rather than a detraction.

How do students react to the array of materials? In general, they react positively. As many of us have seen, students tend to appreciate any extra effort that is devoted to the course. A simple web, with obvious paths, seems to prevent the chance of students getting lost. However, I learned that the students were not necessarily as resourceful as I thought. I had expected that the URLs at the top of every page would make it trivial for them to
find other resources. However, I would occasionally receive reports that a page was not available online, when it was available, but I had neglected to add it to the appropriate index.

Unfortunately, the results on effect of learning also appear less positive. While the WWW-based materials clearly aided some students, they also had negative effects on other students. Again, this is an instance in which instructor guidance can ameliorate the negative effects. Students need to be reminded that there are a variety of learning styles, and while some may learn better by “thinking rather than writing,” others need to take notes in order to cement ideas in their mind [Carrier 1983]. It is important to help students learn how to take notes in conjunction with electronic blackboards, and not use the blackboards as replacements for their own notes.

However, for those who can benefit from more active participation and less note taking, these strategies seem particularly helpful. The class notes I use are quite informal — little more than partially-organized notes to myself on the topics I plan to teach, the ideas I hope to cover, and the general structure of the examples I expect to use. Often, what I end up teaching bears little resemblance to the set of notes I hand out. Other course webs use tightly-edited sets of notes that may be of equivalent quality to a chapter in a published textbook. Some use the web as a slide authoring tool, so that the printed outline can precisely match the projected slides or blackboards. I made the dual decisions to use informal outlines and to do separate blackboards for a number of reasons.

In discussions with students, I found that many object strenuously to any form of prepared slide. Some object because they feel that slides prohibit a free flow of ideas in lecture; in their experience, instructors who use slides are not willing to look at materials from a different perspective, or to try an untested experiment in front of the class. Others object because they feel that slides encourage “lazy teaching”; in their experience, instructors who use slides have generally not bothered to rethink the material since they first created the slides. While neither perception may be correct, such negative perceptions can adversely influence student reactions to the course, and therefore decrease student learning. I also find that avoiding slides can better involve students: if students know that they can participate in the discussions, influence the direction of the course or lecture, and have their suggestions taken seriously, they will be more willing to speak up.

The decision to use informal, rather than formal, notes was less motivated by student reaction and more by personal inclination. I find little use for formal sets of notes, given that students already have textbooks that can serve the same purpose. Informal notes can, however, highlight key ideas and provide a glimpse into another perspective for understanding the material. They can also give the students structure for discussion without excessively biasing the discussion.

Summary

For this course, the use of WWW-based resources has been successful. The students in this course, like most college students, are still discovering how they learn. As such, it is still important for instructors to design the web in such a way that students are guided to more essential materials, while still having access to additional materials. Similarly, students should be reminded that there are different learning strategies, and not all strategies work for all students. With proper guidance to students and thought given to the overall design of the course web, WWW-based resources can be a successful addition to any course.

References


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Toward a Software Engineering Discipline for the Modeling and the Design of Hypermedia Distributed Applications

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Abstract: This paper describes a software engineering methodology for the design of distance learning environments integrated in hypermedia distributed systems such as the World-Wide Web. The proposed methodology is based on a formal model, called Hierarchical Time Stream Petri Net (HTSPN), which establishes sound foundations for the prototyping and design of hypermedia applications on distributed asynchronous systems. With the help of the proposed methodology authors can design robust and correct distributed hypermedia applications.

Introduction

During last few years, we can notice an increasingly growth of hypermedia information bases available over services such as the World-Wide Web (WWW) which is an information system globally distributed over the Internet [VETTER94]. The contributions in terms of openess, accessibility, extensibility and portability of the WWW make it the unquestionable choice for the design of global multimedia/hypermedia applications. In particular distance learning environments are well suited to be used over WWW, and experimental systems have been already suggested [ANDREWS95] [LITTLE95] [WOLF95]. Students can interactively access to a course all over the world without using further tools. As for teachers, they may combine various media to build their course and easily make use of other ones by only making a reference link towards the target resource.

However, the design of a hypermedia system over the WWW is not an easy task. Indeed by tackling large information spaces, hypermedia systems introduce paradoxically the important problems of user disorientation and information overload [CONKLIN87]. Moreover, the design complexity of hypermedia systems is increased by the need to have an explicit notion of time for the management of multimedia scenarios [ARDMAN94].

Therefore, the design of hypermedia systems is a complex task which makes the use of a software engineering methodology greatly relevant. So, we propose a new formal model called Hierarchical Time Stream Petri Net (HTSPN) allowing the whole characteristics of a hypermedia distributed system to be modeled in a unifying way [SÉNAC95a]. Moreover, from the HTSPN model, we have developed a modeling methodology and a software
The first part of this paper motivates the use of HTSPN. Then, the second part illustrates our modeling methodology whereas the third part introduces the prototyping toolkit. Finally, the fourth part is dedicated to the integration of HTSPN specifications into the WWW.

The HTSPN model

Three fundamental conceptual structures can be identified for modeling hypermedia systems: semantic structures that specify links (i.e., user interactions), logical structures that specify composite components (i.e., multimedia nodes) with the help of encapsulation mechanisms, and temporal structures that specify the dynamic behavior of a composite component. Several models have been proposed for the modeling of hypermedia systems, but unfortunately up to now, there is no formal model that allows semantic, logical and temporal structures to be fully and easily expressed through a unifying way [SENAC96].

The Time Stream Petri Net model (TSPN) has been initially introduced for the modeling of temporal structures inside multimedia distributed systems [SENAC94]. This model allows the temporal variability of processings in asynchronous distributed systems to be taken into account. Indeed, using TSPN multimedia processings are modeled as times arcs associated with a three-tuple (min, nom, max) which specify respectively the minimal, nominal and maximal durations of the related processing. Moreover, a firing semantic associated with each transition allows the synchronization non-determinism introduced by the temporal variability of processings to be controlled through a complete set of nine synchronization semantics [SENAC94]. We have also put in the limelight that a TSPN can be reduced to a temporally equivalent timed arc [SENAC95a]. This property lays the basis of the logical abstraction capability of the Hierarchical TSPN model (HTSPN) [SENAC95b]. Indeed, logical structures can be specified with the help of logical places which abstractly represent temporally and structurally equivalent TSPN. The recursive use of logical places allows several abstraction levels to be defined for a specification. Finally, semantic structures are easily modeled as timed arcs outgoing from link type places. Modeling links as timed arcs allows timed and dynamic links to be easily specified [COURTIAT96]. Therefore, the HTSPN model allows the three fundamental structures of hypermedia systems to be uniformly modeled with timed arcs, using a minimalist approach.

Figure 1 describes the HTSPN specification of a learning environment made up of two classes. At once, we can notice that bold and dotted places represent respectively link and logical places. This example puts in the limelight the use of a link type place, i.e., place \( P_{12} \), for the modeling of two user interactions. Link \((P_{12}, T_2)\) allows the processing associated with \( P_{c1} \) to be stopped at any time. Indeed, a master strategy related to a master temporal validity interval \([0, +\infty]\) models a synchronization scheme only driven by link \((P_{12}, T_2)\). This scheme specifies that the triggering of this link produces a new execution of the processing related to \( P_{c1} \). Moreover, if we suppose that this event occurs at relative time 2, it entails the interruption of \( P_{11} \) and the «skip» of \( P_{12} \) and \( P_{13} \).
in the subnet associated to place $P_{c1}$. As for link $(P_{c2}, T_3)$, according to the weak-and firing rule, it specifies that the processing related to $P_{c2}$ can only start when the processing related to $P_{c1}$ is ended and when link $(P_{c2}, T_3)$ has been triggered inside its temporal validity interval $[4,15]$.

**The modeling methodology associated with HTSPN**

Our modeling methodology is based upon a software engineering approach. The precise and complete specification of synchronization constraints in hypermedia distributed systems is a complex issue. Therefore, formal approaches are of the greatest relevance in order to depict this kind of specification with the help of simulation and analysis techniques. So, we suggest a modeling methodology based on HTSPN providing a support for the specification of synchronization constraints in hypermedia distributed systems [ABRE95a].

Two main axes have been marked out in order to define our modeling methodology. Firstly, the concern of HTSPN hierarchical capabilities allows a system to be specified using some modular cutting out techniques as step-wise refinements. Secondly, an emphasis of assistance to the author through his modeling process is supplied by a set of verification, simulation and analysis techniques integrated in a software engineering toolkit.

**HTSPN hierarchical capabilities**

The proposed modeling methodology based on HTSPN may be stripped into a two layers model (figure 1). The upper layer, so called semantic and logical synchronization layer specifies the dynamic behavior of a hypermedia distributed system with a high level of abstraction. This layer, made up of link and logical places, is not necessarily structured and cycles may be used. The lower layer, so called temporal synchronization layer, is dedicated to the specification of temporal constraints within composite components. This layer composed of structured TSPN [SENAC96] only made up of logical and atomic places allows the author to hierarchically specify a hypermedia system. Therefore, by using HTSPN hierarchical capabilities author can model a hypermedia system according to a bottom-up, top-down, or « yo-yo » approach. A bottom-up approach allows the author to build his specification in an ascending way by referencing, with the help of logical places, previously specified and validated TSPN. Conversely, a top-down approach allows the author to put first his effort on high level modeling considerations whereas lower level modeling issues are delayed by using logical places which will be refined afterwards in an incremental way. Moreover, some complex specification can generate HTSPN hard to manage in a monolithic way. So, the proposed methodology benefits from the modular and encapsulation mechanisms offered by logical places and their related subnets. The recursive use of logical places allows to define several abstraction levels for a specification.

**Specifier assistance**

The proposed methodology emphasizes the assistance given to the author by combining the specification stage with verification, simulation and analysis techniques. These techniques allow logical and temporal inconsistencies to be detected inside a specification, and establish the foundations of a methodology for prototyping hypermedia systems.

The verification allows the author to statically check the consistency of his synchronization schemes in order to detect desynchronization risks. Indeed, this unit allows the author to consequently modify his specification by changing the synchronization schemes submitted to potentially desynchronization risks. Given that HTSPN use a «best-effort» synchronization semantics, HTSPN synchronization semantics try to preserve for the best the temporal constraints of a favoured processing. However, because of temporal drifts between the processings involved in a synchronization point, the temporal constraints of the elected processing may not be satisfied. Therefore, a worst-case analysis aims to check that transition firing is always done inside the temporal validity interval of the favoured synchronization unit.

After the verification step the author can carry out a dynamic and interactive simulation of his specification in order to study its dynamic behavior. Interactive simulation can help to get additional understanding of the modeled system which can be considered and used as a prototype of the real system. Moreover, automatic simulation can detect failures in specification and can be used for debugging and performance evaluation purpose. Indeed, the statistic exploitation of results stemming from simulation samples can reveal itself a powerful tool.
Finally, an analysis step allows an exhaustive study of both logical and temporal properties of the HTSPN specification to be done from its underlying timed state graph.

Modeling life cycle

We introduce a modelling methodology based on a two-dimensional life-cycle (figure 2). Indeed, a first spiral life cycle is entailed by combining the specification, verification, simulation, and analysis capabilities offered by HTSPN. Therefore, a HTSPN specification can be iteratively modified according to temporal and logical undesirable properties detected along the verification, simulation and analysis steps. On the other hand, a second life-cycle is entailed by the hierarchical capabilities of HTSPN. Indeed in the early stage of the modeling process, the author has a partial and imprecise knowledge of the real system. This imprecise knowledge can be abstractly expressed by logical places which will be refined later on. This second life-cycle allows top-down and bottom-up modeling approaches to be used and combined. We can notice that the step-wise refining methodology allowed by logical places entails a hierarchy of modeling layers. Moreover, simulation, verification and analysis techniques can be either selectively applied to one specification layer or globally to the whole specification.

The HTSPN toolkit

In order to assist the author in applying our modeling methodology we have designed a software engineering toolkit that provides tools for the whole stages of a hypermedia distributed system prototyping : specification, verification, simulation and analysis [FABRE95b].

The specification unit provides the previously evoked hierarchical and modular capabilities and allows a HTSPN to be built through a visual formalism based on a digital video production studio composition paradigm.

The verification unit allows synchronization units potentially submitted to desynchronization risks to be put in the limelight. In order to suppress or to reduce these risks, the author may either change the synchronization strategy of the related transition, or modify the temporal validity intervals of some upstream places. An automatic correction is also proposed in order to help the author to consequently modify his specification.

The simulation unit allows the author to study the dynamic behavior of the specification by considering the temporal non-determinism of distributed systems with the help of probabilistic or deterministic distributions associated to temporal validity intervals. The specification execution is symbolized by the tokens progress throughout the considered HTSPN. In order to make easier the understanding of the system state, visual cues are associated to tokens. Therefore, a color code characterizes the temporal state (early, on time or late) of synchronization units (i.e. multimedia processes) and a shape code symbolizes their processing state (running or ended). All dynamic temporal information (enabling dates, processing durations, transition firing dates...) are stored in order to analyze them later on. At any time, the author can interact on the simulation. First of all, he can modify or suppress random events in order to see how the specification reacts in case of failure. He can also put
breakpoints in order to set the granularity level of the simulation and increase time step by step or up to the next breakpoint. A temporal analysis unit allows at any time the author to exploit temporal information (jitter, drift...) associated to synchronization units and multimedia streams.

The analysis unit aims at the exhaustive analysis of the temporal and logical properties of HTSPN specifications. This unit is not yet developed but theoretical bases are acquired and consist in an extension of the validation method introduced for Time Petri Net by [BERTHOMIEU91].

The next part shows how real hypermedia documents can be designed over the WWW with the help of HTSPN. This capability opens the way to the automatic generation of HTML documents from validated specifications built using the previously evoked software engineering methodology.

Integration of a HTSPN specification into the World-Wide Web

The WWW is today the greatest distributed information service, providing a huge data base of multimedia information dealing with many various topics. It represents a privileged place to build and to test distance learning applications. In its current form the WWW is an extended hypertext system allowing to browse a set of pages (i.e. HTML documents) interconnected by hypertext links. Each page is built from a set of multimedia data referenced by links (figure 3). A presentation player is associated with each kind of media. Therefore, a presentation page consists in calling the whole presentation players related to the media found in the page. However, the WWW cannot be considered yet as a real distributed hypermedia system and offers only a subset of the capabilities covered by the HTSPN model.

![Figure 3 - Example of a hypermedia system over the WWW](image)

Indeed, in its current form, the WWW does not allow distributed hypermedia documents to satisfy temporal and synchronization constraints. Because of its inability for tackling multimedia synchronization, the WWW is not able to design real hypermedia documents, that is logical networks of multimedia presentation scenarios interconnected by hyper-links. In order to suppress this limitation with a strict compatibility with the current WWW implementation, we proposed a method allowing to play synchronized multimedia objects over the WWW without changing HTML and HTTP. Indeed, a new kind of resource has been easily added into the WWW: a multimedia node related to a TSPN specification. A multimedia presentation player has been developed in order to take into account the temporal and synchronization constraints inside multimedia nodes [CHAPUT95]. Based on this approach, a WWW system is defined as a network of multimedia nodes interconnected by links. Such hypermedia architecture can be easily modeled with a HTSPN. Indeed, we have noticed that multimedia nodes can be modeled as logical places associated to an underlying TSPN. As for WWW links, they can be specified as HTSPN link type places whose outgoing arcs have temporal validity intervals equal to $[0, +\infty]$ (i.e. WWW is not able to provide timed links), and whose outgoing transitions are associated to a master synchronization semantics (i.e. this synchronization schemes are exclusively driven by link activation). Therefore an immediate mapping can be done between a so constrained HTSPN specification and its HTML representation. This consideration opens the door to the automatic translation of HTSPN into HTML and allows arbitrarily complex WWW hypermedia extended documents to be produced from fully validated formal specifications.

Conclusions and perspectives

[1] HyperText Markup Language is the standard language for designing hypermedia documents over WWW.
We have introduced a software engineering methodology for the modeling and the design of complex hypermedia distributed systems. This methodology based on a formal model and its related software engineering toolkit allows robust and correct distributed hypermedia system to be designed on the WWW. The proposed methodology allows authors of hypermedia systems to easily and fully specify the fundamental structures of hypermedia systems using a formal model that offers powerful simulation and analysis capabilities.

This methodology and its related toolkit have been successfully experimented for the modeling of distributed multimedia systems [FABRE95b]. The toolkit extension to the HTSPN formalism is under development and will be used for the prototyping of a distributed computer aided learning environment for Airbus Training [SÉNAC95b]. At last, we have shown that the current hypertext capabilities of WWW can be powerfully extended with the help of the HTSPN mode, and that the design of WWW hypermedia applications can greatly benefit from the introduced methodology. Moreover, this methodology allows WWW documents extended by multimedia synchronization capabilities to be automatically designed from a formal specification.

As a conclusion the logical, temporal and semantic complexities of the future large hypermedia and cooperative distributed applications that will be supported by upcoming large-scale high-speed distributed systems will make necessary the use of formal methodologies as the one introduced in this paper for mastering their robustness and correctness.

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Learning To Learn By Doing By Doing

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Abstract: The CaBLE Tutor (Case-Based learning-by-doing environment) is a computer-based learning environment that provides a simulation experience with the guidance of an “expert” tutor. This paper describes “The Recursive Tutor,” a CaBLE Tutor that teaches people how to design CaBLE Tutors for different knowledge domains. In the Recursive Tutor, the learner is given a knowledge domain and learning objectives, and must specify the appropriate actions, learning goals, role, stories, interface items, and feedback to be used in the Tutor. Learners will have access to a hypermedia knowledge browser and an expert designer who offers advice when needed and can test their design with hypothetical end-users to obtain feedback on its effectiveness.

People learn best when they are highly motivated by a “real world” important goal. In other words, if they are engaged in a task that is perceived as meaningful and engaging, they will be motivated to complete it, and they will learn the facts, skills, and knowledge necessary to complete that task in the process. The Case-Based Learning-by-doing Environment (CaBLE) Model creates this kind of learning environment -- one which closely matches the way people most naturally learn. CaBLE Tutors are computer-based learning environments that provide a simulation experience with the guidance of an “expert” tutor, as well as access to knowledge and resources pertaining to the knowledge domain involved in the simulation.

CaBLE Tutors are effective learning tools that can have important implications for the design of educational software and training materials, as well as the way we approach education in general. Andersen Consulting, for example, uses a CaBLE Tutor called HeRMiT as part of a Business Practices Course, which reduced their training time by 40 % and saved the company $10 million in payroll and training costs the first year. Users of CaBLE Tutors have reported the experience to be engaging and effective in helping them understand the principles and issues being taught in the tutor. Similar computer-based tutoring systems have also reported analogous success stories. In short, the CaBLE Tutor has been shown to be an effective model for utilizing multimedia to teach.

The Problem -- Teaching People to Build CaBLE Tutors

In order for a development team to successfully build a CaBLE Tutor, four conditions must exist:
1. They must understand the principles that underlie a CaBLE Tutor;
2. they must believe it is a good model;
3. they must have the skills to create a design that applies these principles to a new knowledge domain; and
4. they must have the skills to actually build a tutor that uses this design.
The first two goals are relatively easy to accomplish. Existing papers and articles seem to have convinced many people that the CaBLE Model is effective for various knowledge domains [Williamson 1995]. Examples shown at Educational Multimedia conferences have also generated a tremendous positive response. In fact similar models are also being used that successfully incorporate components of the CaBLE design.

Assuming there is agreement that the CaBLE Tutor is effective, why doesn’t everyone build them? We believe this is because the third and fourth goals can not be accomplished as easily, for the very reason we build CaBLE Tutors in the first place -- the inherent complexities involved in the CaBLE Model make it difficult to learn how to design and build a CaBLE Tutor for a different knowledge domain by just hearing about one.

For example, many decisions must be made in the process of designing a CaBLE Tutor, and the designer must have a good model of how an “expert” accomplishes the tasks involved in the simulation. It is often difficult to generalize this information to new knowledge domains. Therefore, designers must have an opportunity to cultivate these skills by actually attempting to build one. In other words, the complexities involved in designing a CaBLE Tutor necessitate the learn-by-doing approach used by the Tutor! Unfortunately, the only vehicle we currently have to experience this learning-by-doing approach is to work with someone who has done it before who can guide you through the process and offer helpful resources and support.

There are also many intricacies involved in the actual construction of a CaBLE Tutor, due to the complexity of the tutoring component imbedded in the system. In the traditional CBT model, the user follows a very predictable linear path [Williamson 1995, p. 74]. In a CaBLE Tutor, on the other hand, the system must respond to the user’s inputs and calculate the end result of those actions, based on an expert model of the knowledge domain. This involves many possible user actions and consequences that the program must be able to simulate. Therefore, in order to build a CaBLE Tutor, programmers must embrace very complex branching structures; CaBLE Tutors are “...difficult and time consuming to build” [Feifer & Soclof 1991, p. 156].

This paper will address the problem of designing CaBLE Tutors in new domains and will describe a tool we are creating, called The Recursive Tutor, to help people cultivate these skills. The Recursive Tutor is a CaBLE Tutor that will teach people how to design CaBLE Tutors for different knowledge domains.

Description of the CaBLE Model

A CaBLE Tutor provides a meaningful, experiential learning environment by taking advantage of the power of computer-based multimedia technology to deliver a guided simulation experience. While learners participate in the simulation, the computer guides them and acts as a tutor by providing them assistance, knowledge, and resources when they request it or when they make a mistake that interferes with their ability to successfully accomplish the goal of the simulation. Assistance is provided via videotaped “experts” who arrive on the scene when needed to share stories of how they made a similar mistake or handled an analogous situation. The use of video helps to bridge the gap between the simulation and reality by making the tutor feel as much as possible like a human tutor who is conversing with the learner and by making the simulation more realistic.

When using a CaBLE Tutor, the learner is placed in a hypothetical, but realistic, scenario and asked to accomplish a goal that is meaningful to him or her; all subsequent tasks the learner engages in are vital to the accomplishment of that goal. Knowledge is not presented to the learner upfront; rather, knowledge pertaining to that domain can be accessed as it is needed to complete the task. After making a fatal mistake in the simulation, learners are told stories by an expert who faced a similar situation. Seeing a “real” person tell a story of a similar situation that actually happened enhances the realism of the simulation. Stories also help learners apply and remember the principle being illustrated; “an appropriate story told in an appropriate setting conveys important information, and ...provides contextual cues that facilitate recall of that information in situations where it is likely to be applicable” [Reisbeck & Schank 1989 in Ferguson et. al 1991, p. 158].

Reasons for a CaBLE Tutor - Why Do We Need It?

A CaBLE Tutor is an alternative to “traditional” computer-based tutoring systems which are very linear and non-interactive. Typically, these systems present information and then test students’ recall of the facts by requiring them to respond to multiple choice questions. This approach does not model the way students process and use information in the “real world,” and information that is “memorized” in this way is seldom remembered
in the future. More importantly, students do not learn the significance of the information because it is taught out of the context of its potential use to students [Collins 1994]. As a result, they are not motivated to learn it, and it has little relevance or application to the "real world". Therefore, a CaBLE Tutor can improve upon this learning experience by providing a safe environment in which to practice skills in a meaningful and realistic way, with the benefit of a tutor that can offer advice and help users learn from their mistakes.

The Human Resources Management Tutor (HeRMiT) tutor [Feifer 1992], for example, teaches human resources principles by placing the learner in the role of a Human Resources Manager. The learner’s task in this simulation is to make human resources decisions without “destroying the company.” The learner has a set of actions that he or she can take, and employees react to the learner’s actions, evidenced by their productivity, morale, and longevity with the company. In this Tutor, learners have access to similar tools that they would have on-the-job, such as employee files and measures of productivity, morale, and ability. When they make mistakes, they are introduced to an “expert” who tells a story about a similar situation he or she faced. Learners are motivated to listen at that point, because they have just experienced the natural negative consequence of the mistake. In addition, they have access to a knowledge browser that they can refer to at any time [Feifer 1992].

The Voice, Image, and Courtesy TuTOR (VICTOR) [Feifer & Soclof 1991] is a similar CaBLE Tutor designed to teach telephone communication skills. VICTOR engages the learner in a telephone conversation with a simulated caller. The dialog proceeds depending on how well the learner performs; if the learner performs poorly, the caller reacts by getting angry or confused. VICTOR diagnoses performance by comparing the learner’s actions with an expert model and locates stories that pertain to mistakes made. Instead of listening to a lecture about telephone skills, they acquire these skills by attempting them and getting feedback.

My Project -- “The Recursive Tutor”

CaBLE Tutors, or any truly interactive systems for that matter, are difficult to design because of the inherent complexity of the design process. This problem applies to all human-computer interfaces, but particularly to CaBLE Tutors because the designer must be able to predict and deal with a wide variety of learner actions. The learner’s role (i.e., telephone operator, human resources manager, etc.) must be carefully designed to compel the learner to pursue a variety of appropriate actions, it must be meaningful and interesting to motivate the learner, and the goals that the learner tries to accomplish through the simulation must compel him or her to perform the target tasks. Then relevant and realistic actions must be selected for the learner to take and an interface created that allows the learner to easily initiate these actions. Feedback must also be given to the learner, and a knowledge browser must be designed which will provide information on the knowledge domain in a way that makes sense for every context learners find themselves in. All of these components must interact successfully within the system to produce the desired learning goals. Furthermore, the Tutor is designed around a model of how an expert would accomplish these tasks, so the designer needs to know the knowledge, skills, and beliefs involved in that domain, as well as the mistakes that can be made and their natural consequences.

In addition, the designer must be able to generalize from an example to a new domain, which requires separating the surface features of a particular Tutor from the essential elements that must be included in every domain. A designer must also adapt those features so that they make sense in the new domain and allow the learner to take actions particular to that domain. Consequently, it is extremely difficult to jump from reading about how to design a CaBLE Tutor, or seeing one, to actually doing it. In fact, it is difficult to design anything by just reading about it --- learning is easier when you get a chance to do it in a meaningful, guided context. Therefore, following the learning-by-doing model, we are in the process of designing a CaBLE Tutor that will allow people to experience designing a CaBLE Tutor in a simulated and guided environment.

Learner’s Role

“The Recursive Tutor”, will allow learners to play the role of an educational software designer who has been asked to design a CaBLE Tutor for the fictitious Learning Company. They can choose from three domain areas to work in; domains are limited to three because the system must store information and expert models for each domain -- this would be impossible to do with an unlimited choice of knowledge domains. Also, since the goal of the Tutor is to learn design skills, not the knowledge associated with the chosen domain, this choice then
becomes a matter of simply selecting a domain that the learner is interested in -- and there is a good chance that at least one of the three choices will be somewhat interesting to the learner.

Learner’s Goals

A learner who is using The Recursive Tutor will be given the goal of designing a “successful” CaBLE Tutor to teach users the target goals and objectives specified for the knowledge domain he or she chose.

Actions

The actions a learner takes in The Recursive Tutor are similar to the things that would be done in the “real world” when designing a CaBLE Tutor, such as choosing a role, choosing a goal, choosing interface items that allow users to take actions and specify the meaning of actions to the Tutor, choosing interface items that will convey information and feedback to the user, specifying mistakes, and obtaining stories to use in the Tutor. Learners will execute these actions by selecting items on a tool palette. They can select input devices, such as buttons, calendars, telephones, or appointment books to allow their users to make choices. Feedback devices, such as meters, charts, character agents, or memos provide feedback to their users.

Resources

During the course of the simulation, the user can get advice from several sources. For example, a senior designer is always available to help whenever the learner asks for it by providing advice on multimedia design, tips for designing CaBLE Tutors, research findings, etc. The designer acts as a mentor, helping the learner determine what to do next by pulling out information from her desk to give to the learner, answering a question through a video, or modeling a skill, if appropriate. The information is stored in a hypermedia knowledge browser, but it is presented through the mentor, making the learner feel like he or she is interacting with a real person. The learner can also consult with a Subject Matter Expert (SME), who provides information pertaining to the knowledge domain. This SME is also a hypermedia knowledge browser, but again, to the learner, he appears and acts like a real person who answers questions by retrieving the requested information from the computer and presenting it in a way that a “real” SME would.

Stories

Throughout the simulation, learners make choices and take actions that will affect the success of the Tutor. There are no right or wrong actions, but some combinations are more optimal than others. Therefore, it is important for learners to choose goals, roles, actions, or resources that will encourage their users to practice the skills they want them to learn. For example, some combinations will allow users to execute more appropriate actions or will facilitate learning the goals for the Tutor, while others will detract from that process. When the user makes a critical mistake during the design process, a videotaped “expert” will arrive who recalls a story of a similar mistake he or she made when designing a CaBLE tutor and how it was successfully handled.

Learners will also be able to get feedback at any point by pilot testing their design with potential end-users. They will receive comments from their users about how easy it was to use, how much they learned, how they liked the Tutor, etc. If end-users liked the Tutor and found that the interface was easy to use, they will provide positive feedback about the experience; if they were frustrated because the actions they were allowed to take did not allow them to accomplish their goals, they will provide feedback accordingly.

Sample Interaction

The learner begins by selecting a project and is then given a description of the facts, skills, beliefs, and concepts that the client wants to be taught through the Tutor. In this example, the learner chooses the “Political Process” knowledge domain to work in, and is given a list of learning objectives from the client, such as “learn how to make an informed decision about a political candidate in an election”.

After reviewing the learning goals for the simulation, she begins to design the Tutor by making a series of choices and taking any one of the available actions. She clicks on the “Role” button first to see a list of possible roles her users can take, such as Candidate, Voter, Campaign Manager, or Senator.
After choosing “Campaign Manager,” she clicks on the “Goal” button to decide what goal her users will pursue [see Figure 1]. She chooses from the following list: create a platform, raise campaign funds, raise a candidate’s standing in the poles, get a candidate elected, or win a debate. She chooses “get a candidate elected.” This is an important selection because the goal must motivate users to complete the goal tasks, and must require them to take actions that will help them learn the objectives. Thus, there are no right or wrong combinations of learner goals and roles, but certain combinations will be more effective than others.

Now the learner chooses icons on the tool palette that represent interface items that will allow her users to execute actions. She chooses the calendar tool and drags this icon to the corner of the screen [see Figure 2]. A dialog box appears which asks her to specify what should happen when the user clicks on the calendar; she chooses actions, such as “schedule a press conference,” or “meet with voter groups.” The learner also chooses the newspaper tool, and a dialog box appears asking the learner to specify actions that can be taken through this interface item. She chooses “write an article describing the candidate’s platform” and “write a press release.” At this point, if she realized that the actions a Campaign Manager would take will not allow the user to accomplish the goal of the simulation or the learning objectives of the Tutor, she could change the role or goal.

Now she specifies which combinations of actions represent mistakes. She notices that one mistake a user might make is to schedule a press conference without creating a campaign platform. She specifies this order of actions as a mistake and clicks on the “Story” button to generate a story pertaining to that mistake. After
searching through the story library, she does not find anything useful and decides to generate a new story. When she clicks on “New,” an interview window opens which contains a series of questions that she could ask an expert to generate a better story. She clicks on the question “Have you ever gone into a conference unprepared?” The expert responds by telling the story, and the learner decides to keep that story by linking it to the mistake.

Now she adds some feedback indicators to the interface. She chooses a meter tool by clicking on the meter icon in the tool palette and dragging it to the screen. A dialog box appears which asks her what the meter will measure. She chooses “projected voting results” and labels the ends of the meter with 0% and 100%, respectively; her meter is a voting poll which measures a candidate’s projected share of the votes ranging from 0% to 100%. This will notify her users of how well they are doing during the simulation.

The learner now clicks on the “Pilot Test” button to test her design with her end-users. A screen appears containing feedback; users indicated that they liked the simulation but they couldn’t do things in Tutor that they would have done in the real world. Based on this feedback, she decides to change her design and clicks on the “Advice” button. The Senior Designer appears and asks how she can help. The learner clicks on the feedback item she did not understand and then clicks on the “Why?” button. The mentor responds with a video clip describing some of the decision points the learner might want to “rethink” pertaining to that feedback item.

Conclusion

We believe that the value of the Recursive Tutor lies in its ability to deliver a hands-on learning experience that models the principles it is trying to teach. This system provides an opportunity to practice designing a CaBLE Tutor with the support and guidance that is not readily available in reality, as well to experience using a CaBLE Tutor to understand what this feels like from a user’s perspective. Because the actions that are taken in the simulation are only those that are integral to the ability to design CaBLE Tutors, learners can practice in a simplified environment. Learners also have the benefit of a hypermedia browsing system containing helpful information they will need as they execute a task. And, more importantly, they can practice and get feedback without the complications of having to build an actual Tutor. Thus, the Recursive Tutor is truly an example of “practicing what you preach.”

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Use of WWW Resources
by an Intelligent Tutoring System

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Abstract: The main object of this paper is to show that HTML documents can be used as pedagogical material under the control of an Intelligent Tutoring System (ITS). A Web browser is used as the medium for the delivery of tests and the teaching of verbal information (declarative knowledge). We also show how to encapsulate a Web browser in order to use it under the control of the ITS. The language used is Smalltalk.

Introduction

The use of hypermedia resources in learning and teaching becomes increasingly ineluctable. This interest was facilitated by the arrival of the WWW (World Wide Web) which offers the possibility to access hypermedia resources available on the Internet. Some problems related to the monitoring and control, by the system, of the student learning process present themselves. For example, the student can very well exit the framework of the course during its navigation on the net and go out to others resources, not under the tutorial system control, of the Internet. In an intelligent tutorial system (ITS) it is important and even indispensable to stay current with the learning activities and actions of the student; the analysis of the reasoning process of the student very much depends on that. The main problem here is the management of the teaching/learning process by the ITS. This paper shows that HTML documents can be used as pedagogical material under the control of an Intelligent Tutoring System using a Web browser (here Netscape) as an interface. The first step for this work has consisted in developing a system to generate tests on the World Wide Web in the setting of an ITS for teaching the Québec road regulations [Nkambou et al. 1996]. The next step consists in the use of such resources by an ITS. This requires the monitoring of the student while he is using a Web browser [Schwarz et al. 1996] and we must establish communications (data exchange) between the ITS and the Web client. The other modules of that ITS have been developed in the SAFARI project. The SAFARI project [Frasson & Gauthier 1994] aims at the construction of simulation-based ITSs for training and at the development of a methodology to sustain such a construction.

To exploit in an ITS all facilities offered by the Web, it is important to settle the problems related to the construction of pedagogical resources and the manner they will be presented through the Web. Researchers have shown that the implementation of pedagogical resources in the form of hypermedia can improve the learning of cognitive skills for some learner [Marchionini 1988] [Jonassen & Grabinger 1990]. Some concepts from the application domain we have chosen being essentially visual (road signs, marks on the pavement,...), the use of hypermedia is well suited for their teaching. However, one cannot hope the student will learn simply by putting to its disposition a set of hypermedia resources [Hammond 1993], it is important to manage their use by the student. In this paper we consider the following aspects:

- The use of a WWW client (in this case, Netscape) as the interface for the presentation by the ITS of verbal information (declarative knowledge) [Gagné et al. 1992], tests, exercises and problems;
- The capture in real time and analysis of the student’s trace (the sequence of actions done by the student while interacting with the Web pages);
- The use of a student model;
- Control over the WWW client during a during the teaching/learning process;
- The communication between the WWW pedagogical resource and the intelligent tutorial system.

To do so we have proposed a structured representation of the subject matter, the ITS has to teach, that takes into account pedagogical resources of type hypermedia, and is able to be exploit them in an hypermedia environment.
[Nkambou et al. 1995]. This model is essentially object oriented, and permits one to see a pedagogical resource as an object whose private state varies according to its nature, and that offers an interface allowing the communication with other components of the ITS by message sending.

After a brief presentation of the architecture of the overall system we present the different types of pedagogical resources that we have retained (at the current time) for exploitation on the WWW and the way those resources have been implemented. Next we show how the Netscape Web browser was encapsulated (transformed into a Smalltalk object) and illustrate the use of such resources in an ITS by examples drawn from a course on the Québec road regulations.

### ITS architecture

We present in this section a summary description of the system architecture of our ITS. The tutorial system is composed of three main components: they are the Curriculum component, the Planner and the Tutor [Fig. 1]. In that figure, rounded squares represent instances of classes. Between parentheses, one finds the name of the class.

**Figure 1. System architecture**

#### Curriculum component

This component comprises two parts: a first part is made of one or many objects that are instances of the class Curriculum (each curriculum describes a subject matter domain from a pedagogical point of view) and the second part is an object of the class Course. A choice of several course can be offered to the learner, nevertheless we place ourselves in the situation where the learner has already made the choice of a course. The attributes of a course (among others, its summary and its preliminaries) determine the intentions of the course builder (purposes of the teaching), and this, independently of a particular student using the ITS. Preliminaries of a course allows to set the targeted audience. The identification of such an audience helps the instructional designer to construct the curriculum. If the ITS detects (by a test to verify if the student knows the preliminaries or otherwise) that some preliminaries are not acquired, then the student would have to acquire these preliminaries before starting with the course. Nevertheless if the curriculum is sufficiently complete the ITS could by itself teach the missing preliminaries.

#### The planner

This subsystem uses the course specification and take into account the learner, as perceived through the portion of the student model that concerns the subject matter (objectives and pedagogical resources available), this subsystem elaborates dynamically the plan for the course. It is in part in this dynamic elaboration of the course that the ITS shows pedagogical competence. There will be re-planning all times the tutor subsystem considers that the learning is less than adequate. The planner proposes teaching tasks (to motivate the student, to recall previous knowledge, to formulate an objective, to present contents, to assess the student...) for the tutor to realize. The planner is responsible of the global aspects of individualized teaching.
Tutor

This subsystem manages the interactions with the learner, realizes the teaching tasks by the choice and use of pedagogical resources (teaching material), controls according to the selected tutoring mode (coaching, critiquing…) the teaching process and the dialogue with the student, replies to remediation needs and to help request from the student, updates the student model... The tutor is responsible for the interactions with the learner and the local control on the teaching process.

WWW pedagogical resource

We define pedagogical resources as the means (exercises, problems, tests, simulations, demonstration, video...) used by the teaching system to support the student’s learning of the capabilities described by objectives. They can also be used to practice or reinforce capabilities that have already been acquired [Barr et al. 1976].

Learning material type

We have produced a taxonomy of pedagogical resources. This taxonomy makes several categories of resources stand out:
- those that support the learning/teaching process (problems, demonstrations, exercises, hypermedia document);
- the expert type resources (advisor, critiquing systems, coach) that work as experts that can intervene in the learning/teaching process to help or to critic the student in a specific activity;
- physical and media resources (simulations, video, sound, pictures,...).

We have mentioned only the main categories of resources, other can be identified. [Fig. 2] shows the hierarchy (partial) of pedagogical resources we consider. In this paper we consider only those pedagogical resources exploitable on the Web.

Learning material modeling

In the proposed model, pedagogical resources can be associated to teaching objectives to support its acquisition. They can also be associated to capacities [Gagné et al. 1992]. For example, a HTML resource can be associated to a verbal information to present it. A test can be associated to a concept to make possible the assessment of the acquisition of the concept at a time selected by the tutor.

This type of test can be generated automatically by using examples, non-examples and neighbor concepts associated to the concept. If the system decides to assess the acquisition of a concept, it sends a message to an instance of the right class of tests. [Fig. 3] shows a subset of the protocol for some of the classes shown in [Fig. 2].

![Pedagogical Resource Hierarchy Diagram](image)

Figure 2. Part of pedagogical-resource hierarchy
HTMLDocument Class

| class name | HTMLDocument |
| superclass | PedagogicalResource |
| instance variables | filename, url, linklist, out |
| class variable | ListOfHTMLDoc |
| comment | Instances present themselves, access student action trace and analyze it |
| class methods | instance creation, new, initialize, listOfHTMLDocument, initialize, present, getTrace, analyseTrace, stayedInsideDocument, hasEnded |

PedagogicalResource Class

| class name | PedagogicalResource |
| superclass | CurriculumKnowledge |
| instance variables | name, description, processId |
| class variables | ListOfPedagogicalResource |
| class methods | instance creation, new, initialize, listOfHTMLDocument, initialize, present, getTrace, analyseTrace, stayedInsideDocument, hasEnded |

HTMLTest Class

| class name | HTMLTest |
| superclass | HTMLDocument |
| class variable | ListOfTests |
| class methods | instance creation, generate: aParameterList, present, getTrace, analyseTrace, stayedInsideDocument, hasEnded, assess, evaluate, result |

| instance creation | new |
| generates | Returns an initialized instance of class PedagogicalResource |

| initialize | initialize |
| initializes the class PedagogicalResource |

| accessing | accessing |
| returns the processId of the receiver |

| updating | updating |
| sets the processId of the receiver to aProcessId |

| generate: aParameterList | generate: aParameterList |
| creates a new instance of a test with the given parameters |
| subclassResponsibility |

| present | present |
| Asks an existing Web-client or a new Web-client to load the Web-page associated to the receiver |

| getTrace | getTrace |
| Gets the hypermedia links used by the student |

| analyseTrace | analyseTrace |
| Analyzes the student’s navigation trace |

| stayedInsideDocument | stayedInsideDocument |
| Returns true if the student has not visited an outside link, otherwise return false |

| hasEnded | hasEnded |
| Returns true if the received process has ended |

| assessment | assessment |
| Returns the result and the details of the student performance |

| evaluate | evaluate |
| Analyzes the student performance and returns a value between (success, fair, fail) according to the test inputs |
| (will be specialize in the subclass) |

| result | result |
| Analyzes the student performance and returns a value between (success, fair, fail) according to the test inputs |
| (will be specialize in the subclass) |

Figure 3: Protocols of some resources class

Example: creating and displaying a simple identification test on the indication sign

```plaintext
|x|
x := SimpleIdentificationTest generate: #('indication' '5 toto')
"x contain an instance of SimpleIdentificationTest on the indication sign concept"
x present
"load x in a Web-browser"
```

In the learning/teaching process, the teaching itself is done at the level of pedagogical resources. However this activity can be decided by the student or by the system according to the tutoring mode chosen. When the system is in charge, the tutor has to decide about the pedagogical resource to put into play (a demonstration, a problem to solve, a test on the acquisition of a concept, content to read, etc.) by taking into account the evolution of the student and the student model. Once an activity is decided, the tutor sends the message to presents itself. As an example, if the resource is a test of type hypermedia then a WWW client is going to show up in the interface, displaying the test and ready for the student to work on the test.

Test presentation through the Web

Tests present themselves as interactive HTML documents (HTML forms) [Fig. 4]. This allows the student to enter its answer, which can be send to a server computer and processed by a program on the server. The treatment of student answers to an HTML document is made possible by the Common Gateway Interface (CGI) mechanism [NCSA 1995] [Liu et al. 1994].
This mechanism makes possible the execution on the server of a script or a program with parameters values provided by the student. It can accept data entered by the user on the client side and generate interactively an HTML document. An HTML form provides a simple way to collect data from the user on the Web. Student results on a test can be captured and put at the disposal of the tutorial system (in tutorial mode) or treated by a program and be returned as a WWW page to the student. Such a page could contain an indication of the student performance.

Navigation trace: analysis and intervention

How to monitor the student once he has been given access to the WWW. The approach we have taken is to use the History file automatically generated by Netscape. By the use of a demon, the tutorial system can check the content of that file in order to know what hypermedia links are followed by the student. Every instance of an hypermedia resource contains a list of the anchors present in the document, so the system can know whether the student is working within the planned pedagogical resource or followed a link out of part of the Web under the tutorial system control. The system can gain control again on the session if it so desires.

Encapsulation of the Netscape browser

In the learning/teaching process, some activities do not necessitate the utilization of the Netscape browser. It is therefore important to manage its presence in the learning interface. To achieve that, we have decided to make an Smalltalk object out of the Web browser [Fig. 5a]. [Fig. 5b] shows part of a WWW object protocol.
The tutor can ask a Netscape browser (instance of the class W3-Client) to put itself in the background simply by sending it the message `hide`. The message `show` brings back the browser. Thus the Web browser is under complete control of the tutorial system and is only available when needed.

Conclusion

We have presented an approach of the exploitation of the WWW documents by an ITS. Several aspects have been explored:
- The presentation of an architecture including a curriculum and a course specification;
- The automatic generation and the presentation of tests;
- The capture of the test results and its availability to the ITS for further treatment;
- The capture of the navigation trace of the student;
- Some aspects of the communication between the ITS and the WWW browser.

The application on which this approach has been built is available on the Internet, and its URL is http://www.iro.umontreal.ca/people/nkambou/menu.html. The arrival of languages such as Java [Fiendly 1995] [Sun 1995] and of Java enabled browsers brings new solutions to problems related to the interactivity of WWW pedagogical resources and to their distribution on a network [Gauthier & Nkambou 1996].

References


Acknowledgments

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Infusion of Telecommunications Technology into a Project-based Curriculum: Running with the River

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Abstract: The University of Findlay, in collaboration with area public schools, is in the second year of a unique partnership whose mission is the infusion of technology into a problem-based learning unit focusing on the water quality of a local river and resulting implications for the Great Lakes. Funded jointly by private industry, state government, and higher education, the project requires teacher teams (Grades 3-11) to mentor an undergraduate teacher education student as they spend one year developing/teaching a water-based unit, using real-world experiences and appropriate technologies. Children and teachers who are geographically distant are networked through various telecommunications technologies. This paper will describe the project and future plans.

Running with the River
Collaboration through Technology

Project Overview

In 1992, teacher education faculty at The University of Findlay made a commitment to actively pursue curricula that view communication and multimedia technologies as indispensable tools facilitating problem-based learning. This was based on the belief that fostering the development of children, both educationally and socially, is critical to the future of our global society. The future will demand that our children develop abilities to communicate effectively, access knowledge, think critically, and solve problems. Communications, data gathering, and decision making will occur at quicker rates than in the past. Technology will play an even greater role. Children are ready and eager to accept the challenge. Their teachers must be prepared to guide them. Teacher education programs that meet the needs of the future will be those that have vision, determination, and the ability to effect systemic change.

With these goals in mind, Teacher Education at The University of Findlay developed an innovative teacher education project entitled Running with the River: Collaboration through Technology. The project involves collaborative efforts among:

• The University of Findlay faculty and students, both graduate and undergraduate;
• School teachers and their administrators from ten districts in northwest Ohio;
• Ameritech Ohio, an Midwestern telecommunications company;
• The Governor’s office of The State of Ohio.

The focus of this in-depth collaboration involves the development and implementation of both preservice and inservice teacher training programs that seamlessly integrate state-of-the-art communications and multimedia technologies into the academic curricula of the university and the public schools. Reconceptualization of the university and public school curricula center around an integrated problem-based program of study focusing on water, specifically, the quality of the Blanchard River as it flows through two adjacent counties in Northwest Ohio as a tributary of the Great Lakes Watershed. Central to the success of the project are portable computers
and a fiber optic communications system linking The University of Findlay and local schools. Spring of 1996 marks the conclusion of year two of the project, with a new set of participants each year.

With the ultimate target being the fostering of self-directed learning in children, the project uses an engaged learning model that requires participating mentor teachers and university students to learn in a way that we hope they will employ as they work with their students in the public schools (Jones, Valdez, Nowakowski, Rasmussen, 1994). To begin their work together as a team, two mentor teachers and a university student develop a vision statement with goals and expected outcomes, which they use as a guide in their teaching, learning, and development activities throughout the year. The developmental levels of each participant are addressed through the individualized and consultation-based strategies of interaction with project faculty.

Major Outcomes of the Project

• Comprehensive integration of communication and multimedia technologies across undergraduate teacher education programs at The University of Findlay and across elementary and secondary curricula of local schools;
• Development of a problem-based and technology-infused, active learning environment;
• Development of a permanent technologies mentorship program, partnering select teachers from area schools with Teacher Education juniors from The University of Findlay;
• Establishment of ongoing educational communication links among The University of Findlay, area schools, and the broader educational community.

Specific Objectives of the Project

• Provide university teacher education faculty and K-12 teachers the necessary skills, expertise and support to integrate communications and multimedia technologies into their courses and methodologies;
• Support the mentorship teams, as well as public school building administrators, as they develop strategies, methods and materials that recognize technology as a critical learning tool;
• Foster communication, peer support and on-going learning by utilizing a topical on-line forum;
• Create a lending library of technology equipment essential for implementation of the communications technology curriculum in the mentor teacher classrooms;
• Initiate an ongoing graduate level summer institute which blends new technologies and problem-based learning, with a focus on community as a research tool;
• Develop in Teacher Education juniors, K-12 children, and their teachers critical thinking and problem-solving skills;
• Evaluate effectiveness of a technology integrated curriculum in a teacher training program;
• Contribute Blanchard River water quality data to The Great Lakes River Basin Project;
• Share knowledge, strategies, skills gained by participants in the project with the broader educational community.

Phase I: Development and Training

This period focused on establishing network communications capabilities, selecting participants, and orienting participants to the project. Also included were development and implementation of inservice for university Teacher Education faculty and public school teachers, as well as curriculum development on both the university and K-12 level. Mentor teachers were selected from a pool of area teachers who expressed an interest and were recommended by their administration. The University of Findlay partnered Teacher Education juniors with the mentor-teacher teams.

Each participant was given an Apple PowerBook portable computer to use throughout the year. Various tools are available to the participants for electronic communication and collaboration, as well as multimedia-based instructional delivery. These include a fiber-optic-based video teleconferencing system, a dedicated World Wide Web server, a POP email server, a FirstClass server, a lending library of peripherals (QuickTake digital cameras, external CD-ROM drives, an LCD panel for projection), additional PowerBooks, and various softwares.

A main premise of the project was the simplification of the interface between participants and their electronic tools. Systems and softwares that provided a graphical user interface were selected for project use.
Considerable time was dedicated to ensuring that each participant enjoyed graphical access from both home and work/school.

Summer work sessions allowed public school teachers and university faculty to restructure their respective curricula in preparation for fall implementation of a problem-based, technology-supported unit of study. Participants (teachers, university students and faculty) were introduced to the Internet and the World Wide Web as a means of communication, data sharing and conferencing with others interested in monitoring water quality of rivers both nationally (specifically, the Great Lakes) and internationally. These hands-on technology sessions were structured to begin the process of moving the participants through the various developmental levels of technology growth.

Phase II: Curriculum Implementation

Teacher education students were partnered with ‘mentor-teachers’ from the public schools, working as a teaching team throughout the year. Each team consisted of two classroom teachers and an undergraduate student. The building principal is also included as in the team to provide administrative support for the teachers. Collectively, all of the teams have chosen to refer to themselves as the RiverTeam.

Problem-based learning which centers on water is supported by technology-rich learning opportunities. University students bring their PowerBooks and digital cameras to their mentor-teacher sites, using the equipment throughout the year to support instruction. Computers can be used by teachers, students and children for data collection at the river, for data analysis and presentation, project/product development and for communication using the Internet. Classrooms can also communicate via a fiber optic video teleconferencing system. The location of participating schools along the river throughout two counties provides the opportunity for students to compare water quality issues from both agricultural areas and a manufacturing town.

The Teacher Education curriculum at The University of Findlay has been reconceptualized, clustering the education methods courses to reflect the problem-based approach being implemented in the public schools. As an example, the integrated teaching of Science Methods, Social Studies Methods, and Children’s Literature was initiated. A effort was made to include technology components in all appropriate courses throughout the Teacher Education curriculum. Freshmen are introduced to technology at the personal management level. Sophomores are required to respond to learning activities and lessons using technology; Juniors are required to incorporate the technology into their lesson plans, and seniors are required to integrate all of their technology learning in the development of appropriate, problem-based learning activities for their student teaching experience. All students are required to use electronic information systems to develop inquiry-based learning skills.

As a result of individual team goals and access to a variety of multimedia and communications tools, participants created diverse teaching and learning materials. Teaching teams allowed their problem-based unit of study to develop in terms of student-generated questions. This process led to diverse applications of technology that ranged from simple overhead transparency production to complex multimedia presentations and development of World Wide Web pages reflecting the work of particular schools.

The work of the RiverTeam has aroused the interest of Ohio’s Center for Science and Industry (COSI). The museum has shared a staff member with The University of Findlay to work with the RiverTeam members as they planned, developed, and implemented teaching activities related to the project. In turn, the RiverTeam was requested by COSI to act as a focus group, in the planning process for development of activities and exhibits at a new northwest Ohio COSI facility.

Phase III: The Future

The project has established an ongoing undergraduate and graduate curricular framework of technology integration, mentorship and communicative collaboration within a consortium of three progressive educational entities in northwest Ohio. Within the adaptable new framework, countless other problem-based learning areas may be studied (e.g. air quality, recycling, political elections) collaboratively among the three entities, utilizing the communication technologies which are currently being piloted. A summer institute for area teachers is one focuses on graduate study in communications and multimedia technologies leadership, but always in the context of problem-based learning.
The University of Findlay’s Teacher Education faculty have contributed to the development of Ohio SchoolNet programs, a state-wide effort to infuse problem-based learning and educational technologies into Ohio’s public schools. Initiated by Governor George Voinovich, SchoolNet projects represent a 500 million dollar investment in Ohio’s schools. Running with the River has allowed The University of Findlay to carry out this growing state-wide initiative on a local level, paving the way for future state-supported technology opportunities.

The impact of the project on teaching and learning is reflected in the comments of Sue Becker, an interdisciplinary art teacher at Central Middle School:

I feel so lucky to have been a part of this project, which has been a renewal to my teaching... To be able to offer kids a chance to research information in a way that they are so “turned on to” makes teaching exciting again. I love to teach but you can burn out so easily from all of the issues that filter into our jobs. It was great to have students and teachers excited, knowing that we are on the cutting edge of technology in our classroom.

Acknowledgments

This project has been made possible through the generosity of Ameritech, Ohio and Governor George Voinovich. The financial and technical support of this telecommunications company is greatly appreciated by both University of Findlay Teacher Education faculty and public school personnel. The benefits afforded to children in our area schools has been wonderful.

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Jones, Valdez, Nowakowski, & Rasmussen (1994). Plugging In. North Central Regional Educational Laboratory
Abstract: This study has investigated the effects on grade-eight students of different numbers of motivational elements in versions of Fred Fraction, a public-domain mathematical drill-and-practice program. Each student used one version of the program and had the choice of using it or a similar control program which was the same for all students. The methodology for the study was a partial replication of a previous study [Malone, 1984]. While the mean time spent using Fred Fraction increased for each version of the program containing an additional motivational element, not all differences were statistically significant. Boys and girls taken together showed significantly greater interest in the intrinsic elements fantasy (graphics) and curiosity (music). Unlike the Malone study, only limited evidence for gender differences was found.

Introduction

The interest by adolescents in arcade games and the enormous increase in the use of microcomputer software in the last decade or so has raised the question as to why arcade and microcomputer games are so appealing to this age group. Developers of educational software have incorporated features of arcade games into educational software as a result of this appeal on the assumption that these motivational features will enhance learning. Unfortunately, as a result of the rush to develop and utilise this new technological resource in the classroom, little systematic work has been carried out to investigate why these materials are so intrinsically interesting and how this interest can be best harnessed to achieve effective learning. [Lepper, 1985] has indicated that "... surprisingly, we know very little about this very fundamental question of how motivation affects learning ... at present there are very few data for guidance". In his theory of intrinsically motivating instruction, [Malone, 1984] provided the first systematic framework in which to study intrinsic motivation in microcomputer software.

The elements of intrinsically motivating environments have been organised by [Malone, 1984] under the three components of challenge, fantasy and curiosity. Challenge depends upon attaining goals with uncertain outcomes. Its components include variable levels of difficulty, uncertainty, hidden information and randomness. In many instances, the concept of challenge requires the development of competence and feelings of efficacy. [White, 1959] argued that humans have an intrinsic need to build up confidence within the environment and that behaviours that satisfy confidence are self-rewarding. For example learning to walk (falling and stumbling) is not extrinsically motivating, but to have learnt the act of walking is self-motivating, therefore intrinsically motivating. Intrinsic motivation can be used to explain exploratory striving toward developing new skills.

Each of these environmental features is linked to goals with uncertain outcomes. Malone argued that goals should take certain forms if they are to be intrinsically motivating. These forms have to be personally meaningful, obvious or easily generated, and need to provide performance feedback which tells the learners whether they are achieving their goal. Furthermore, an environment should also provide goals that have an uncertain outcome. This can be attained by: variable difficulty level, multiple-level goals, hidden information, and randomness. Research by [Wood, 1990] supported Malone in showing that children perform best when given multiple-level goals. Finally, Malone argued that a challenging microcomputer environment should enhance the individual's self-esteem and that the learning activities should be sensitive to failure as well as success. In order to accommodate this sensitivity, the instructional activities should have variable-difficulty levels.
The second component of an intrinsically motivating environment theorised by Malone is fantasy. Features of such an environment include graphics, characters and story plots. Malone made a distinction between extrinsic fantasies and intrinsic fantasies, with extrinsic fantasies being remotely linked to the skill being used and intrinsic fantasies intimately linked to the skill. Several authors [Malone, 1984]; [Lepper, 1985]; and [Wood, 1990] have posited that fantasies are based upon emotional factors whereby the individual can identify with the elements at a personal level. Games possessing war, destruction and competition characteristics are likely to be more popular than those with less emotional fantasies. [Piaget, 1951] suggested that fantasy in children's play is an attempt to absorb experience into existing structures in the child's mind with minimal needs to accommodate to the demands of external reality.

The degree to which an intrinsically motivating environment can arouse and satisfy our curiosity is, according to Malone, of utmost importance. [Berlyne, 1966] proposed that curiosity in a new situation is an inbuilt device for incorporating novelty, complexity, surprise and incongruity in cognitive structures. For Berlyne, positive intrinsic motivation occurs when the mismatch between environmental demands and developing cognitive structures is at its optimal level. The optimal level for intrinsic motivation would therefore occur when there is an appropriate level of conflict between existing knowledge and the new knowledge to be learned. Malone distinguished between two types of curiosity, sensory and cognitive. Sensory curiosity involves attention and the attractive value of changes in the environment, e.g. light and sound. According to [Wood, 1990], children respond best to auditory and visual stimuli, and she found them not detrimental to learning for the learning-disabled children studied.

The motivation for this paper is grounded on the Darts game research conducted by [Malone, 1984] which suggested that boys and girls are motivated differently by particular motivational elements. As no further work appears to have been published since then supporting or repudiating that finding, it appeared timely to clarify the position further, since as Malone indicated, the gender difference in preference that he found may be explained by the aggressive nature of destroying balloons with weapon like objects. Hence this study is a partial replication of his methodology and seeks, in the context of mathematical drill-and-practice software, to determine the differential effect of motivational elements on intrinsic motivation, as well as considering any associated gender effects using a non-aggressive graphical element.

Unlike the results of the Malone study, it was predicted for this study that intrinsic motivation, as measured by the time spent using the particular version of the program, would be dependent on the number of motivational elements contained in it, and that no gender effects would be found.

Methodology

The public domain program Fred Fraction was selected as it was suitable for use with grade-eight (first-year Australian high-school) students. As well, it dealt with the same topic, namely fractions, as the Darts program used by Malone in his study, albeit in a different manner. The motivational effect of the material itself could then be reasonably assumed to be similar. In order to determine the cumulative effects of motivational elements, Fred Fraction was adapted to fit the following six conditions in order to partly replicate the conditions used by [Malone, 1984]:

- **Version 1:** No feedback: this version consisted of a series of operations with fractions (worksheet style);
- **Version 2:** Scoring: this version was in the same format as Version 1 with the addition of an end-of-session score that could be obtained by pressing the "escape" button;
- **Version 3:** Performance feedback: this version was in the same format as Version 2 with the addition of a comment: "Well done your answer is correct." or "Your answer is incorrect." after each response;
- **Version 4:** Constructive feedback: this version was in the same format as Version 3 with the addition of a comment: "Your answer is too high." or "Your answer is too low."
- **Version 5:** Graphics: this version was in the same format as Version 4 with the addition of a graphical representation (blocks) of the fractions to provide an intrinsic fantasy element; and
- **Version 6:** Music: this version was in the same format as Version 5 with the addition of music to provide an intrinsic motivational curiosity element (high-pitched music if the answer was correct and low-pitched music if the answer was incorrect).

For each version mentioned above, routines for scoring, performance feedback, constructive feedback, graphics and sound were progressively called upon.
Sixty-eight thirteen to fourteen year old students from two randomly selected mixed-ability grade-eight classes took part in the experiment. This convenience sample was assumed random as the allocative model used by the school to form classes at this level attempted to achieve, as much as possible an even mix of ability and socio-economic level in each class as possible. Individual students were randomly assigned to one of the six versions of the treatment program Fred Fraction together with a control program called Drill and Practice. The control program Drill and Practice consisted of a series of whole-number and fraction drill-and-practice calculations and possessed score and performance feedback elements. Fred Fraction and Drill and Practice were of comparable difficulty levels.

The students were allocated one thirty-minute session and given the freedom to work with the two pieces of software alternating from one to the other as they so desired. In order to determine the time spent playing each game, the students recorded the time when they started and stopped playing each game. On the completion of the individual sessions each student was asked the following questions: "How would you rate Fred Fraction on a scale from 1 to 5?" and "Which game did you prefer?".

These data generated the three variables Time Spent (min), Liking (1-5), and Preference (0-1) which were used in later analyses. While the dependent variable Liking was ordinal, an approximation of continuity was assumed in this case to compare ANOVA results with those of [Malone, 1984]. An approximation of continuity was not assumed for the variable Preference as it was dichotomous. Two-factor ANOVAs were generated to answer the following research questions:

(i) Is the main effect for Version Number significant for each of the dependent variables Time Spent and Liking?
(ii) Is the main effect for Gender significant for each of the same two dependent variables?
(iii) Is there a significant interaction between Version Number and Gender for each of the two dependent variables?

An additional research aim was to determine the strength of the relationship between the three variables, Time Spent, Liking and Preference as measured by the Pearson r, in order to determine to what extent the three variables were associated. It was an assumption of this study, and that of [Malone, 1984], that these three variables provided reasonable indicators of students' motivation to use the software.

Results

The frequencies and means are displayed for the independent variables in each cell with respect to each of the dependent variables Time Spent [Tab. 1] and Liking [Tab. 2].

<table>
<thead>
<tr>
<th>Version</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
<th>V6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count(N=)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Females</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>11</td>
<td>14</td>
<td>11</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Means(min)</td>
<td>15.0</td>
<td>18.8</td>
<td>14.0</td>
<td>20.2</td>
<td>22.8</td>
<td>25.7</td>
</tr>
<tr>
<td>Males</td>
<td>10.4</td>
<td>11.4</td>
<td>20.4</td>
<td>21.0</td>
<td>22.0</td>
<td>25.5</td>
</tr>
<tr>
<td>Females</td>
<td>12.7</td>
<td>15.5</td>
<td>17.6</td>
<td>20.6</td>
<td>22.4</td>
<td>25.6</td>
</tr>
</tbody>
</table>

Table 1: Frequencies and means based on the dependent variable Time Spent.

<table>
<thead>
<tr>
<th>Version</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
<th>V6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count(N=)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Females</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>11</td>
<td>14</td>
<td>11</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Means(min)</td>
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<td>2.83</td>
<td>2.00</td>
<td>3.17</td>
<td>3.80</td>
<td>3.83</td>
</tr>
<tr>
<td>Males</td>
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<td>2.80</td>
<td>3.60</td>
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</tr>
<tr>
<td>Females</td>
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<td>2.82</td>
<td>2.93</td>
<td>3.00</td>
<td>3.70</td>
<td>4.08</td>
</tr>
</tbody>
</table>

Table 2: Frequencies and means based on the dependent variable Liking.
The results from Tables 1 and Table 2 indicate that for both dependent variables there was an apparent increase in the overall means from version number one to version number six, that is, as the number of motivational elements increased so did the motivation to play the game as indicated by the two measures used. This is not the case for the individual means for males and females where for both dependent variables, there appeared to be gender differences in interest between versions two and three of the program, that is, in performance feedback. Differences between the means, as determined from the ANOVA will now be considered.

The results of the two-factor ANOVA for the independent variables Version Number and Gender and the dependent variable Time Spent indicated that the main effect of Version Number was significant ($F = 8.259$ for $p < 0.0001$ and $df = 5$), whereas there was neither a significant effect for Gender nor for the interaction between Version Number and Gender, although this interaction approached significance at $p = 0.066$. A Fisher PLSD post-hoc test, generated from a further one-factor (Version Number) ANOVA, indicated significance at $p < 0.05$ between the means of version numbers: 1 & 3, 1 & 4, 1 & 5, 1 & 6; 2 & 4, 2 & 5, 2 & 6; 3 & 6; and 4 & 6. Hence, no adjacent versions gave rise to significant increases in interest.

The two-factor ANOVA for the independent variables Version Number and Gender and the dependent variable Liking indicated that the main effect for Version Number was significant ($F = 6.676$ for $p < 0.0001$ and $df = 5$) and that there was neither a significant effect for Gender nor for the interaction between Version Number and Gender, although the interaction approached significance at $p = 0.055$. A Fisher PLSD post-hoc test generated from a further one-factor (Version Number) ANOVA indicated significance at $p < 0.05$ between the means of version numbers: 1 & 5, 1 & 6; 2 & 5, 2 & 6; 3 & 5, 3 & 6; 4 & 6; 5 & 6. Hence, only one adjacent pair of means gave rise to a significant increase in interest, namely version five with graphics and version six with music added.

Calculation of Pearson correlation coefficients indicated significant relationships between all three combinations of the dependent variables Time Spent, Liking and Preference for $p < 0.01$. Also, as there was no significant interaction between Version Number and Gender in the two-factor ANOVA reported above, separate analyses for boys and girls were not carried out. Hence, comparison with the separate gender analyses carried out in the Malone study was not feasible.

**Discussion**

The statistical analysis for the main effect of Gender showed no gender differences with respect to Time Spent across all versions of Fred Fraction, but did show significant differences in interest for various versions irrespective of gender, since the main effect for Version Number was strongly significant for both dependent variables used. The results from the Fisher post-hoc tests indicated that boys and girls together showed significantly greater interest in the intrinsic elements fantasy (graphics, version five) and curiosity (music, version six) compared to the elements used in versions 1-3. The results also suggest that while there was no significant difference for boys and girls taken together when an end-of session score was added to the first version, the further addition of performance feedback had a significant effect on Time Spent. This differed somewhat from the [Malone, 1984] study where the version with performance feedback was not significantly more interesting for either girls or boys, taken separately, than the adjacent version without this element.

The finding that the interaction between Version Number and Gender approached significance for both dependent variables used provides limited evidence in the present study for a difference in interest between boys and girls in performance feedback, with the boys being less interested in this feature than the girls. The [Malone, 1984] research using the Darts program showed a strong interaction between Version and Gender, and that boys preferred the intrinsic fantasy element (graphics) compared to girls. The present research does not support his findings. Suggested reasons for these differences are outlined below.

Firstly, Malone's intrinsic element consisted of arrows popping balloons on a number line if the correct answer was given. The intrinsic element in the present research was a graphic representation of the fraction if the correct answer was given. This graphical element appeared above the symbolic expression and was more removed and hence less 'intrinsic' to the concept than the [Malone, 1984] representation. There is no evidence from the present study as to the extent to which the students chose to refer to this graphic. Also, on comparison of the graphical elements in the two studies, Malone's intrinsic graphical element possessed a higher level of aggression, namely the arrow bursting the balloon. This may have confounded the results in his study as the males may have been attracted to more aggressive element.
Secondly, Malone's research was conducted with two twenty-minute sessions whereas this research, by force of circumstance, was conducted using one thirty-minute session. The students involved in this research may have distributed their time differently if they had been given an interval whereby they were able to think about their liking and preference. This may have affected the time spent playing Fred Fraction in the second twenty-minute session.

Research by [Wood, 1990] relating to young children with disabilities did not focus upon gender differences with regard to intrinsic elements. She did find, however, that a prominent feature of intrinsically motivating software was fantasy, multiple-level goals and the opportunity for children to make decisions. The present research does support Wood's findings in relation to fantasy in that the fantasy element for this research was contained in version five (intrinsic graphic), the mean for which was significantly greater than those of versions 1-2 for Time Spent and for those of versions 1-3 for Liking. The significant differences between the mean scores also provided evidence for increased motivation between versions 1-4 (Time Spent) and version six, and versions 1-5 (Liking) compared to version six. Hence the music (sensory curiosity) element also appeared to have a significant effect on interest.

The fact that there was only one significant increase in interest, as measured by Time Spent and Liking, for all of the ten adjacent pairs studied suggests that, if students are going to spend time using and enjoying microcomputer software, the design of such software should include a variety of interest measures.

The evidence from this study also suggests that graphical representation, together with aural feedback, will provide a more motivating and interesting mathematical learning environment for individualised learning. However, because this current research was conducted with drill-and-practice software, the discussion must necessarily be restricted to this software type. Also, while the research suggests a cumulative effect produced by the motivational elements used, increased sample size in future studies of this type may provide a clearer view of this effect and also help to determine whether a gender difference exists for performance feedback.

[Sanders, 1984] claimed that girls both liked music videos and liked to know how they perform to a greater extent to that for boys. While there was no significant interaction with respect to gender for the performance feedback and music versions for the sample of students involved in the present study, there was limited evidence that performance feedback was favoured by the girls.

Conclusion

This study examined the effects of motivational elements in a mathematical drill-and-practice learning environment. The key result of the experiment was that students are intrinsically motivated by curiosity and fantasy in drill-and-practice software and that when students are motivated by a piece of software, they are content to spend time with it, enjoy it and prefer it to other software. The study has also shown that students are motivated to a lesser extent by performance feedback and constructive feedback.

In contrast to the [Malone, 1984] research, this work has not generated any evidence to support the argument that gender differences exist with respect to motivational elements, although it does point to a possible difference in interest in performance-feedback elements. The research does, however, strengthen Malone's argument that in order to make learning environments more motivating, the use of captivating microcomputer software, which includes fantasy and curiosity elements, should be encouraged.

The research also goes some way in confirming Malone's claim that "... varying specific features in a set of nearly isomorphic games seems to be a useful way of empirically studying intrinsic motivation". Future research may extend the conditions used in this study to include, for example, variable levels of difficulty and interpersonal competitiveness and co-operation. Also, extending the study of motivational elements beyond drill-and-practice software to other software types may help to inform the software evaluation process by better enabling educators to more accurately predict the intrinsically-motivating potential of new software on the market.

References


A WWW Microworld for Mathematics

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Abstract: This paper discusses the components and implementation and the use of a WWW
learning environment, i.e. a microworld for the mathematical sciences. Existing (RTF,
LaTeX) lecture notes are converted into HTML documents and hypertext links are generated
automatically into them. In addition to the text, the hypertext courses contain a database of
concepts, problems, examples with hints and interactive exercises. A computer algebra
system is used to generate and randomise exercises and to check the students' answers.
Animations and video clips are used to clarify mathematical ideas. E-mail, bulletin boards
and videoconferencing software are available on the system to enhance interaction between
the teacher and the distance learners.

Introduction

In this paper the design and the implementation of a microworld or a hypermedia based learning
environment on the World Wide Web (WWW) for the mathematical sciences will be discussed. This paper is an
outcome of a national scale project lead by the Hypermedia Laboratory at TUT, supported by the Academy of
Finland and the Finnish Ministry of Education. The main purpose of the project is to produce mathematical
hypercourses on the WWW that can be used nation-wide at schools, institutes, and universities, everywhere
where Internet is available. As such, Internet provides an inexpensive medium to transfer the material to different
sites and with WWW browsers the courses can be studied in different environments (UNIX, PC and Macintosh).

The pilot material consists of two courses: a basic mathematics course for students starting their studies
at university level and a course on matrix algebra. The purpose of the first course is to revise school mathematics
and to provide help and support for mathematical problems that students will be facing at the university level.
The structure of both of the courses consists of text, mathematical dictionary or database of definitions of
mathematical concepts, exercises, examples and computer aided interactive exercises. Some mathematical ideas
and problems are clarified with animations and video clips. The mathematical concepts in the lecture notes are
linked to the corresponding definitions in the mathematical dictionary or the definition database to provide on-
line help for understanding them. Exercises, with hints and examples, are given as a part of the lecture notes. The
symbolic algebra package, Mathematica, is used for interactive exercises; it generates different numerical and
symbolic exercises, and checks the answers given by students.

The structure of the hypermedia courses is based on the experiences that the authors have got from
constructing a stand-alone hypermedia learning environment for Macintosh—see [Antchev et al. 1995b],
[Multisilta et al. 1994a], [Multisilta et al. 1994b] and [Pohjolainen et al. 1994]. Positive classroom experiences
encouraged us to extend the basic design ideas for this WWW version.

Communication between distant learners and teachers will be supported by bulletin boards, e-mail and
videoconferencing software. The data transfer speeds at the university vary from normal modem speeds up to
155 Mb/s using ATM-network.

The presented hypermedia courses will be used in an experimental way to support distance learning
through the Internet. A special group for distance learners will be formed and experience on distance education
with the proposed system will be collected and analysed.

Converting Lecture Notes into HTML documents
The WWW courses can be based on existing text books or lecture notes. In our department quite a lot of lecture notes have been written with Microsoft Word (RTF) or LaTeX. In both cases the raw text can easily be converted with existing public domain (PD) converters. The quality of the converted text is rather good, but major problems were encountered due to the specific features of the mathematical notation, such as subscripts, superscripts, Greek alphabet and other mathematical notation not supported by HTML 2.0. In the future, when the browsers support HTML 3.0, it will be possible to use super- and subscripts in a much more elegant way. However, mathematical formulas have still to be converted from RTF or LaTeX to HTML 3.0. The quality of the final output depends on the WWW browser and the size of the selected font. Changing the font size in the browser does not scale the pictures, which is a bit annoying.

From Latex to HTML

There are several PD converters that convert LaTeX to HTML. Our choice was LaTeX2HTML by Nicos Drakos from the University of Leeds [Drakos 1994]. As pointed out by Drakos this conversion is inherently difficult. This difficulty stems mainly from the fact that a converter cannot be aware of all the possible user-defined LaTeX-macros.

A mathematical dictionary was written with LaTeX and it contains many postscript figures and mathematical formulas. Mathematical formulas were converted into GIF format by LaTeX2HTML. This results in quite a lot of small picture files for each page. Due to the difficulty mentioned above we have implemented some LaTeX macros in the dictionary as Perl scripts. These macros are used mainly for including pictures in HTML documents.

From RTF to HTML

An RTF file contains text, formatting commands, pictures and formulas and is used to transfer documents between different word processors or computer platforms. Many word processors can read and write RTF.

RTF files can be converted to HTML documents using a PD converter called RTFtoHTML [Chris 1995]. However, it does not convert super- and superscript or Greek letters to GIF pictures. This is why a preprocessor was programmed in Macintosh environment to read the RTF files, to search for super- and subscripts and to write them as RTF representations of pictures into the corresponding places in the RTF file.

RTFtoHTML converts pictures and formulas to Macintosh pictures (PICT). They have to be converted to GIF format using another converter. Most of the WWW browsers read GIF files that are binary compatible, so that GIF files can be created in Macintosh and then transformed to UNIX, where many WWW servers exist. Graphics files should be saved in transparent mode, so that they will be displayed well even if the background colour in the WWW browser is not white.

In order to handle Greek letters the RTFtoHTML converter was customised by modifying certain configuration files. In our case the Greek letters are displayed as GIF pictures. Every time the converter encounters a Greek letter it places the corresponding HTML tag in the HTML file.

Creating Links Automatically to HTML Documents

Our WWW courses contain several hundred HTML files. Thus it was necessary to create hypertext links automatically. The material was divided into files so that a subchapter corresponds to a file. In addition, the definition of each mathematical concept was saved to a file. This file structure made it possible for us to implement a powerful tool for automatic linking, called Linktool.

Purpose and Usage of LinkTool

Linktool was written in C and it runs on a Unix platform. The purpose of the program is to add links to HTML documents. The program is fairly easy to use. The user just has to write the hot words into the so called link file.

The format of the link file is simple. A line in the link file contains just one hot word or phrase, which is the anchor of a link, and the corresponding target. The target of link a is a path to a HTML file or any URL. In order to handle phrases with several words, such as "Normal Matrix", they must be written into the link file before single hot words, such as "Matrix".
Morphological Aspects

In the Finnish language there are many inflected forms of a word. Other European languages sharing this feature are for example Estonian, Hungarian and Bulgarian. Because of inflected words, it is difficult to identify all the occurrences of the hot words in the text.

Linktool solves this problem in the following way. First it tries to find out the stem of the word. When the stem is found, the program adds nearly all the possible endings to the word. The program uses regular expressions as search terms, in special GNU regexp package and strsed function, written by Terry Jones. Both of these are public domain software available for example from [Cdrom 1994]. The next example shows how the program adds some Finnish word endings using regexp engine. The regexp, given below, matches with the basic form of a word "matriisi" (matrix) and all the inflected forms, such as "matriisit" (matrices), "matriisina" and "matriisin".

\[ matrii[bcdfghjklmnpqrstvw][bcdfghjklmnpqrstvw]*([aeiouy]|ä|ö)[aeiouy]|ä|ö]?(na)?(ta)?(n)?(en)?(jen)?(in)?(ssa)?(lla)?(lle)\] /

Interactive Exercises and Experiments

A computer based learning environment should provide feedback for the students. Interactive on-line exercises form such an activity.

In a typical interactive exercise the computer will pose a problem and ask the student to fill in an on-line form. In some cases the user may be asked to answer the problem. The answer will be assessed and a message will be returned describing whether the answer is correct or what went wrong. The form may also serve as an aid for solving the actual problem. By submitting such a form the students may get a plot and/or results of calculations intended to help them, as it is for "Conic Sections" — an experiment described in Section 5.1.

Often we would like to randomise a part of the problem's data, so that the students can work out several problems of the same type, successively. They may explicitly ask for 'new values' to be generated by pressing a designated button, or they may simply arrive several times at the same node. From the authors' perspective, the users' inputs and the browsing history are valuable sources of information that are needed to improve the quality of the hypermedia materials.

The existing client- and server-side standards on the WWW support the development of distributed interactive applications using standard HTTP clients and servers. Our interactive exercises are such applications. For mathematics the ability of the server side to perform nontrivial numerical computations and symbolic manipulations is essential. Therefore, the idea of incorporating an advanced computer algebra system as part of the server-side software is natural. Mathematica® is such a system with powerful numerical, symbolic and graphical capabilities [Wolfram 1988]. It was chosen, because of its excellent communication protocol, namely MathLink [Wolfram 1992]. Mathematica's programming language, a high level interpreted language with a vast amount of built-in functions and a sophisticated pattern matching mechanism, has been used to code the algorithms for generating the problems' data, processing of the forms' contents and creating aesthetically pleasing plots. The availability of various Mathematica packages further simplifies many programming tasks, especially in mathematics. We have also written our own packages—one per interactive exercise—to encapsulate the code for each exercise and for ease of its maintenance. To present mathematical formulas in the exercises we use Mathematica's two dimensional form, made up of several preformatted lines of characters, which we surround by \(<\text{PRE}>\) and \(<\text{PRE}>\) tags (abbreviation from preformatted). Plots, which are created using Mathematica and then converted to GIF format, are presented in-lined in HTML documents along with explanatory text and other information.

Studying on the WWW Learning Environment

A general view of the learning interface in the course of Matrix Algebra is given in [Fig. 1]. The studying material consists of lecture notes divided into chapters and subchapters, a concept definition database, exercises, interactive exercises, animations and videos. In [Fig. 1] the student is reading the subchapter on the Jordan Canonical Form. On the left hand side there is a page from the lecture notes (in Finnish).
The links starting from the mathematical concepts to their definition files can be seen as the anchor words and they are underlined or of a different colour. The mark-up of the links can, of course be set by the user using the preferences menu of the WWW-viewer. The student has also opened a video tutorial that shows how to find the Jordan Canonical Form for a given matrix. We have found these videos interesting and useful. First, they give a possibility to pass the student information in the form that resembles lectures or tutorials. At each stage of the solution the video tutorial presents the theoretical results that are needed for the next stage. The hand-writing in the video window is used to tell the student: this is what you should do. Since video clips contain sound they give a possibility to pass oral information to students. This is useful to teach the pronunciation Greek letters, names of mathematicians, (foreign) names of methods and so on. Looking and listening to the video may help the student to solve a related interactive exercise, generated by a symbolic algebra program Mathematica (lower right hand corner). From this point of view it is useful that the video can be stopped and be viewed frame by frame. Once the student has found the solution, he or she may write it down in a box provided and after that have the computer to check solution and to inform the student about the result. The correct solution can be seen by pressing the "Show the right answer" button. If the student wants to find the Jordan Canonical Form for another matrix, he may ask for a new matrix by pressing the "New Values" button. Care has been taken to keep the problems sufficiently simple. All the matrix algebra interactive exercises can be solved with integer matrices, with small integer elements. Currently there are 15 interactive exercises in the course of matrix algebra.

Figure 1: Learning interface of the WWW-microworld.

[Fig. 1] does not present all the studying possibilities in our WWW microworld. In addition, there are exercises, mostly theoretical, with two hint levels. The first hint level explains the problem in more detail and the second hint level informs about the right path for the proof or the solution. All this textual material is given as
hypertext and links to the definition files are available. At the end of the hypertext lecture notes a student can find previous examination problems. These can also be read as hypertext with links to the definition files and they can be used also astest questions for self study.

At the end of each page there are two buttons which give possibilities for student-teacher interaction. The student can open the bulletin board of the course by pressing the leftmost button at the lower left corner of the lecture notes in [Fig. 1]. The button on the right opens a form for e-mail between the student and the teacher.

Interactive Experiment on Conic Sections

"Conic Sections" is an interactive experiment in the course of basic mathematics. This exercise shows that the proposed learning environment supports mathematical experimentation and learning by doing. The experiment consists of several HTML pages which can be viewed with standard WWW browsers. The example seen in [Fig. 2], can be studied on our WWW server [Antchev et al. 1995a] and it runs as follows.

![Figure 2: Learning interface with an interactive experiment and video connection to the teacher](image)

Page 1: A second order equation describing a quadratic curve in the xy-plane is generated randomly by Mathematica and the student is asked to determine the type of the curve.

Page 2: The second page will be displayed, if the question on Page 1 is answered correctly. The new problem, related to the same curve, is to bring the curve into its canonical form using coordinate transformations. The computations are carried out by Mathematica. Students are asked to enter the parameters of the coordinate transformations. To help them identify these parameters, the curve is plotted.

Page 3: The curve is presented in the new coordinate system both as an algebraic equation and as a plot. The students can see the effect of the coordinate transforms and compare their plots with the correct one. They may return to Page 2 to adjust some of the parameters until the desired canonical form is achieved.

Interaction Between Students and Teachers
Although the designed courses are suit well for self-study, interaction between distant learners and teachers is very important. In the future the distant students may enrol the open university by filling out an online WWW-form. In studying the material they might have problems with the lectures and the exercises and they would like to ask for advise or help. The final examination needs to be organized and the results should be sent to the students. The designed hypermedia environment supports student - teacher interaction on several levels. For each hypermedia course a bulletin board will be set up. The bulletin board is in fact an usenet newsgroup and it is visible to every student. In the front page of the WWW course they find a button to open the bulletin board. Students may also contact the teacher in a more personal way. At the end of each page of the hypernotes they may find buttons to send e-mail to the teacher. This feature will be used to give the students personal assistance, to receive their solutions to given problems and to give them personal feedback. The possibility of attaching documents with e-mail is especially useful, since it allows the sender to point out details on the WWW material.

In addition to e-mail connections and bulletin boards the students and their teacher can also use videoconferencing software for their meetings and discussions. With ShowMe on Sun [Sun 1995] and CU-SeeMe [CU-SeeMe 1995] on Macintosh and PC it is possible to establish real-time videolinks. It is not possible to open a videolink from a HTML document to a specific address automatically. Currently, the videolinks have to be opened manually by launching the videoconferencing software and entering the information needed to establish a connection to the teacher. However, the developers of CU-SeeMe videoconferencing software are planning to create an URL specification to open a videolink using HTML.

ShowMe includes audio, shared applications, video and whiteboard. It uses TCP/IP-protocol and supports Ethernet and ATM. With the Ethernet maximal speed of 10 Mbit/s picture refresh rate may be low and voice may be cropped. The available ATM-connections allow speeds of up to 155 Mbit/s, so that the quality of video and audio is better. Audio provides 8-bit 8 KHz at 64 Kbps. Audio traffic can be multi- or one-way. Shared Application works with X11-compliant applications. A user can start applications that the other users can see and use. Applications run in the local computer and only send display to other participants screens. Video lets the users see all the participants and take images from participants video-windows. The quality of the video is not yet sufficiently good to show teaching with e.g. chalk and blackboard. Text and pictures can also be shown using special shared application called Whiteboard. Participants can see the Whiteboard and write or draw messages on it.

Conclusions

In this paper a hypermedia based learning environment, i.e. a microworld, which supports self-studying and distance learning on the WWW has been presented. Technical aspects in converting linear text in popular formats (RTF, LaTeX) into HTML have been discussed. The main components of the environment are automatically linked hypertext, a database of definitions, exercises and examples with hints and interactive exercises where an on-line computer algebra system is used to generate and randomise the problems and to check the answers. Interaction between the teacher and the distant learners will be supported by bulletin boards, e-mail and finally with videoconferencing software. An experimental group of distance learners will be set up to test the proposed learning environment both from the technical and the educational point of view.

References


DIALECT: Digital Interactive Lectures in Higher Education

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Abstract: Can computer-based hypermedia learning material improve the quality of education in an university environment? In this paper we describe a new method and an integrated concept for the creation and distribution of digital interactive lectures (DIALECT) over a broadband communication network. Basically a "real story" that illustrates the theory to be presented is developed and integrated into the lecture. This is accomplished with the help of interactive video which is used to present the topic, to guide through the parts of the lecture and to catch the students' attention. DIALECT makes use of animation, computer simulation, and hyperlink facilities and enables the developer to include the appropriate media where needed. The lectures are stored on a UNIX multimedia server and can be presented on Windows based PC clients using a high-speed LAN. Special attention has been paid to the user front end in terms of screen design and good video quality. A framework for programmers and authors that allows an efficient use of the presentation tools has been developed.

Problems and issues

Due to the wide availability of inexpensive multifunctional personal computers, computer-based learning has become increasingly attractive. The establishment of stable and efficient networks as well as the technical integration of audio, video and digital computers open new ways and opportunities for creating and distributing multimedia learning material. Multimedia applications are an extraordinary boost to distance learning; however, a lot of technical [Bodendorf 95] and didactic [Zimmer 92] problems remain unresolved [Niegermann 95]. Apparently most of the major approaches of computer-based learning will contribute to increased flexibility (open learning), improved independence from time and place (just-in-time learning), and be a weight off lecturers' chests.

Comprising over 5,000 students, the department of economics at the Free University of Berlin is one of the largest in the Federal Republic of Germany. This necessarily leads to large audiences in basic as well as advanced courses. Even though all traditional types of tuition are being employed (lectures, tutorials), the support for the students remains poor. Various evaluations of teaching quality at the faculty [Eval 94] revealed a significant correlation between students assistance and learning curve. Since tutorials are very staff-intensive, the attempt to further amplify traditional types of training has to be discarded for financial reasons.

Making headway towards a solution

A viable alternative to employing additional teaching personnel could be the creation of interactive hypermedia lectures. This new way of learning on one's own initiative will enable students to deal with the multimedia learning material before or after classes and in accordance with their individual progress in learning. In that way, teachers can concentrate on actual problems, current issues and special topics. The use of navigation and visualization techniques such as hyperlinks, interactive graphics, video sequences, animation, simulation and man-machine interaction contributes essentially to the understanding of abstract contexts and theories [Paivio & Csapo 73]. For this reason, overall knowledge transfer can be expected to improve substantially [Beuschel et. al.
As the learning environment is optimized [Reinhardt 95] a better utilization of the university resources and improvements in the students’ performance can be expected.

Three large universities, several research and educational establishments characterize the scientific landscape of Berlin, Germany, with over 100,000 students. The educational facilities are spread up over the whole city. Many students would like to attend classes offered at other institutions if they were locally accessible. Many teachers would be just as pleased to offer joint lectures in co-operation with colleagues at other institutions preferably at no travel costs. For this purpose an experimental broadband communication network was established in 1995. BRAIN, Berlin's Research Area Information Network, is based on a fibre optic 155 Mbit/s ATM network that connects the main educational and research institutions of the city. In parallel to BRAIN the German National Research Network (WiN) has established a 34 Mbit/s ATM virtual backbone (B-WiN) [Kaufmann 95]. Both BRAIN and B-WiN provide the necessary infrastructure for networked multimedia applications. Working in multimedia computer pools, students can access through the network digital learning material at various places [Baumgartner & Payr 94]. At a later date, private homes could be also connected to the broadband network.

Figure 1 gives a brief overview of the technical infrastructure:

The aims of DIALECT

There are various forms of teleteaching [Effelsberg 95] that differ from one another according to the underlying approaches and goals. Computer based telecommunication and interaction between teachers and learners (the concept of virtual classrooms) [EDUCA 95] as well as interaction models amongst students [Vassileva & Lehmann 95] is of primary importance. For example, real time (video) transmission of a lecture as well as video conferencing [RTB 95] make the presence of a lecturer or an expert indispensable. CBT courses and off-line video transmissions, on the other hand, can be retrieved and studied at any time (just in time) as long as the interaction with an expert is not needed. Mixed models of human interaction have been used in various projects supported by the European Community [DELTA 95].

Based on various experiences from other projects [Dette 94] the main objective of DIALECT is:

The distributed multimedia learning material of DIALECT is intended to enable students to learn with minimal human expert consultation.

Additional DIALECT objectives are:

- the end user equipment must be a multimedia Windows-based PC
- the applications have to make use of the existing network infrastructure
- the implementation model must be flexible with regard to the lecturers’ varying requirements
- the learning model should be adaptable to new scientific achievements and industry standards
the own part of the basic software development should be kept minimal

Given the objective of minimizing the interaction with the teacher, high-quality interaction with the computer and the various media (audio/video) is necessary which will be a kind of a substitute for the missing expert. Evidently this calls for a fairly comfortable man-machine interface. Ideally, the user should expect an application which is self-explanatory and, being an integral lesson, also self-contained. The learner should not feel abandoned when trying to follow the instructions. What seems to be a good strategy in order to achieve this goal is a mixture of the rather inflexible but straightforward classical CBT model [Steppi 90] and the extremely unstructured open learning environment [Herzner & Kappe 94]. Given the requested client platform the proper integration of all media could help to build a new model. The basic problem to solve is therefore:

the development of principles and the design of user friendly (human) teachware.

For the design of digital interactive lectures (DIALECT), after carrying out various experiments [Giardina 92] the project team opted for the followinglearning model architecture:

- link together theory and practice by including a practical case study
- navigate through the lecture by means of a guided tour in the form of a suitable story
- design an intuitive end user interface
- keep in mind the main results of the learning theory while building the application sections
- integrate aesthetically aspects into the front end in order to keep the application attractive
- include elements which motivate the learner

In addition to the basic design rules the typical computer tools for knowledge representation like animation, simulation, hyperlinks to related topics as well as calculations and "what-if"-analysis are integrated. Figure 2 illustrates this specific approach.

![Figure 2: The DIALECT approach](image)

It is evident that the currently existing man-machine interfaces are in fact the weakest point of computer-based learning. The present approach tries to overcome these weaknesses by favorably combining the existing multimedia tools. The most demanding in this context are the video sequences with regard to hardware as well as network resources. Moreover, film production clearly is a new field to data processing experts. To develop applications of this kind, it is necessary to form a team made up of various specialists [see Fig. 3]. As a matter of fact the DIALECT team is structured according to this diagram. This was a key issue for the later achievements. It must be stated however that it is far more complicated to build and lead a true multimedia team than a classical software development team. It can be compared to the experiences made with expert systems teams.
Implementation environment

When specifying the requirements for the implementation environment, some restrictions have to be considered that are imposed by the overall goals of the project and the nature of our users. Firstly it must be taken into account that teachers and students in the associated departments make heavy use of PCs with the common operating system software. Secondly, the requested video quality and the lack of storage capacity in servers and clients as well as the current transmission speed of the networks make the use of video compression mechanisms a must. In the case of DIALECT, the MPEG-1 format was chosen. Additionally, the scalability of the multimedia server requires a UNIX-based platform. And finally, the programming environment should offer the flexibility needed for implementing the interaction with the user and the navigation control.

Choosing the right development environment for the client part of the application is of strategic importance. DOS/Windows is being used widely in economic departments. The first prototyping experiences were made with Multimedia Toolbook, but the results were not very promising. Particularly the relatively poor interface capabilities and the inadequate scripting language functionality were the main weak points. We therefore switched to Visual Basic (with various add-ons like business graphics, spreadsheet calculation, hypertext word-processing, image effects etc.) as the main authoring and programming environment to achieve the necessary combination of flexibility and productivity. All of the selected additional hypermedia libraries can be used with the C language also.

The process of media production and postproduction takes place on quite heterogeneous environments (UNIX workstation, PCs) and covers audio, video, and picture digitizing and editing. Workstation systems have great advantages over PCs, especially in the field of media-postproduction because of the quality and functionality of the available software and the workstations' processing power.

The handling of digital videos is still a challenge. An ideal solution would be to encode the analogous videos into a digital format on-the-fly (e.g. Motion-JPEG) that can be edited and manipulated efficiently. The digitized and edited videos would then be converted into the final presentation format (e.g. MPEG). Unfortunately, common solutions (still) favor hybrid approaches (i.e. reconverting the processed material to analogous videos). General solutions supporting the way starting from the analogous point of departure to the final digital end-product are quite hard to find. In accordance to the well known software life cycle, the production of DIALECT lectures can be structured as follows [see Fig. 4]:

Apart from media production, the structuring and transfer of knowledge is a further focal production step. To this end, popular description techniques (storyboards) were adapted and, in a task-relevant manner, extended by
further elements (hypermedia storyboards). In this way, authors and programmers succeeded in converging and developing a common language.

A dedicated UNIX-based multimedia server is used for storing and distributing the completed hypermedia lectures. Since we have to support DOS/Windows clients the digital lectures and objects must be available in a corresponding format. The lectures are accessible via NFS. It is planned to use other protocols (e.g. RPC) in order to reduce overhead and increase the availability. Some design takes place to use powerful DBMS for storing and retrieving the multimedia objects on the backend site. In the near future, part of the communication between the clients and the server will be carried out by ATM high-speed data transmission.

At the moment (almost) all hypermedia objects are maintained in a reference database and loaded dynamically into the application at runtime. Moreover, external object management and storage is a vital pillar for the creation of multilingual lectures.

Case study

The first DIALECT lecture pertinent to Advanced Studies in Marketing and Sales for Engineering Equipment is completed and will be soon used in practice. The contents of the corresponding seminar are based on a case study developed by the Harvard Business School in the late sixties, named Optical Distortion Inc. It deals with the theoretical aspects and practical problems arising from the launch of new, highly innovative products [ODI 75]. By systematically going through the topics of the case study, the participants are provided with information about the company, the product's purpose and important data to tap the new market. Furthermore several units of the lecture supply knowledge of marketing strategies and required instruments as well as the understanding of common mathematical models to simulate the diffusion processes of product inventions. The seminar's final objective is to develop a marketing strategy by means of the theory of diffusion in order to successfully introduce the new product.

The selected story deals with a small company that owns a patented product which substantially reduces the cannibalism among live stock in chicken farms. A newly hired graduate takes on the task of elaborating a marketing strategy. For this purpose she has a digital reference work providing theoretical knowledge and a number of tools (i.e. computer programs) at her command [see Fig. 5]. A true expert (her former university professor) is available whenever problems arise. In the story's course, the dialogue with him leads her from theoretical topics to the recommended exercises. The young professional eventually feeds the calculated results into the system and is informed on whether the estimated parameters will lead to success or not. The system does not include any specific artificial intelligence components that evaluate the output's quality. Since the problems addressed here are known to the lecture it is fairly easy to give students the appropriate help. Interfaces to the outside world like internet, mail, word processors etc. are provided. A history function and a guided tour are also available.

At the end of the lecture, the student is given the opportunity to watch a video-recorded debate of a panel of true marketing experts. This part of the lecture is unique and cannot be easily incorporated into a real lecture. To provide as much interaction as possible, the expert discussion is commented on, hotspots are attached and references are given. It takes a number of hours for the student to get through the DIALECT-lecture and complete the exercises.

The seminar clientele is composed of undergraduate students and graduated engineers. Hence the didactic aims differ. Students have difficulties in converting their theoretical knowledge into practical decisions and the engineers are more troubled with the task of grasping the theoretical background necessary to develop (mathematical) models. The study is to afford relief by putting the students in a position where they are decision-makers and by pointing out to the engineers how to enhance the quality of decisions by including essential theoretical approaches into the problem solving process. Equally they learn to optimize and structure the information and the methods of analysis.
First results
As the project is currently still in progress (January 96), only a preliminary report can be given about the first DIALECT lecture described above which is now completed. It was beta-tested by students and will be put into "production" soon.

Nevertheless, some of the experiences gained with DIALECT so far can be summarized as follows:

- All testers (students and lecturers) are quite impressed by the actual integration of the different media. The vision of a human application consisting of a combination of learning material, a user-friendly interface, and rich interactive video seems to be very valuable. Especially the role of the video that acts as a guided tour, as a knowledge carrier, and as an entertaining element is very much appreciated.
- The length of the lecture doesn't pose any specific problems. The students like the fact that the lecture is complete and contains a large portion of knowledge. The prototype version did not attract anybody. The navigational component is well done.
- The application can be distributed and used over a broadband digital network. The client part of the application needs 10 MB of storage, the server part requires around 620 MB of storage.
- To run the application over the network a constant transfer rate of 1.5 Mbit/s is needed for the transmission of the compressed videos (S-VHS quality). Within an IP environment add an overhead of 1 Mbit/s.
- The integration of different experts is a difficult task and thus makes a project of this kind a complicated and risky affair. See the experience with AI-teams consisting of experts, programmers, and knowledge engineers. However, new professions combining the necessary hybrid skills are likely to emerge.
- The appropriate hardware and communication equipment is poorly supported by popular PC operating systems. For the near future, the most significant improvements are probable to occur in hardware. Today, hypermedia objects are still too large for extensive commercial use.
- The current operating systems and user interfaces do not facilitate the creation of hypermedia applications. GUI tools need complete redesign. For example, the management of rectangular windows only is not sufficient for a flexible hypermedia front end.
- The stability and flexibility of video codecs calls for drastic improvement. Today only experts are able to produce digitized compressed video of acceptable picture quality.
- Authoring software systems (authorware) are still inadequate and incomplete. Especially in the case of building and using interactive video applications, further development is very important.
- There is no common "style-guide" for designing highly interactive, intuitive hypermedia lectures.
- It seems to be a challenge to write good stories for the topic to be processed.

Future plans
On closer examination, working experience shows clearly that expenditure for the development and efficient distribution of digital lectures is (still) considerable. From that we can derive some hints for further improvements:
An increment of productivity seems to be necessary. The economical production of digital lectures is essential to establishing modern teaching materials as a new, complementary instrument of higher education. In this respect, the application framework's generic character needs to be enhanced.

The smaller the gap of comprehension between experts/authors and programmers, the better the implementation and knowledge transfer concerning content and didactic approach will succeed. That is to say corresponding description tools (hypermedia blueprinting) have to be optimized. Moreover, efficient design tools help improve overall productivity.

The internet is an ideal platform serving to reduce the distance between requesters and providers of information. However, some of its fundamental attributes (small range of interactive features, simple data model etc.) contradict the internet's notion of being an exclusive medium for highly interactive, resource-demanding applications. Further advancements in the field of hybrid approaches (integrating HTML, IP-interface) will create new synergetic effects.

Forthcoming applications will necessitate more and better hypermedia objects. Storage and distribution of complex objects must be geared to this development, their organization as reusable objects will increase overall performance and economy.

At university, the entirety of teaching material is quite complex. A lot of time and experience are necessary to find out which components in particular of this multitude are suitable to be transformed into hypermedia material. Therefore, further applications should incorporate state-of-the-art knowledge profiles in order to study their feasibility and suitability.

Since the degree of motivation and inspiration is highly influential on students' performance, another vital question is how the use of (scientific) games can enhance the effectiveness of digital lectures as common teaching material.

After the successful evaluation of the DIALECT model and inclusion into the existing curricula, co-operation with publishers and suppliers of communication services is planned in order to produce and distribute hypermedia lessons beyond the bounds of the university.

References and additional bibliography


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Intelligent Agents to Support the Effective Collaboration in a CSCL Environment

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Abstract: For Computer-Supported Collaborative Learning (CSCL) environments we propose intelligent agents that assist the learners and cooperate in order to create possibilities of effective collaboration in a virtual community of practice. We have developed two kinds of software agents: mediator agents which play the role of facilitators that support the communication and collaboration among learners, and domain agents, which provide assistance concerning the appropriate application of domain knowledge in the network. Mediator agents cooperate exchanging their beliefs about the capabilities, commitments and goals of the learners. Doing this each mediator agent is able to construct a representation of its learner's collaboration possibilities in the group (referred as the learner's group-based knowledge frontier), considering the social and structural aspects of knowledge development. The mediator agent proposes the learner to commit to tasks that require the application of knowledge elements in the learner's group-based knowledge frontier, which results in an increment of the collaboration possibilities between learners, the creation of zones of proximal development [Vygotsky, 78], and therefore more learning possibilities.

1. Introduction

Currently there is a need in the modelling of software for collaborative learning environments supported by networks [Crook, 94], and in the design principles and structures that lead to effective collaboration between learners [O'Malley, 94]. In a Computer-Supported Collaborative Learning (CSCL) environment it is necessary to provide the learners with an environment that helps them to relate new knowledge with the knowledge they have already internalized, as well as tools that help them to identify, compare and integrate different interpretations of the same knowledge [Wang & Johnson, 94].

One of the problems in Japanese language teaching for foreign students in Japan is to determine the most relevant, appropriate, feasible and useful knowledge to teach to a newcomer, considering her/his social context and learning goals. In GRACILE (Japanese GRAMmar Collaborative Intelligent Learning Environment) [Ayala & Yano, 95a] we are currently working on the development of intelligent agents that support the application of domain knowledge and the effective collaboration between learners. By the term effective collaboration we refer to the situation when a learner can learn from other learners while s/he performs a task which demands the application of knowledge elements believed to be internalized by other learners, and which are also considered feasible to be internalized by the her/him, relevant for the acquisition of more complex knowledge elements in the domain and popular among the members of such community of practice. GRACILE has been designed for small heterogeneous groups, from two to four students. We have implemented GRACILE in a local area network of Macintosh computers, communicated via Ethernet. Foreign students collaborate by writing a dialogue in Japanese in a virtual workspace, working from different buildings of the two campus in our University.

In this paper we introduce the general characteristics and the modelling issues of the software agents in GRACILE, presenting how they assist the learners and how they cooperate in order to maintain the possibilities of effective collaboration in a CSCL environment.
2. Software Agents for Collaborative Learning Environments

An intelligent agent is considered a system which behaviour is determined as a result of a reasoning process based on a representation of its attitudes, such as beliefs, commitments and desires [Wooldridge & Jennings, 95]. Currently there have been proposals of including intelligent agents in collaborative learning environments [Norrie & Gaines, 95], [Ayala & Yano, 95a]. Norrie and Gaines have introduced the Learning Web as a distributed intelligent learning environment, introducing an agent-based collaborative learning system. In our research we propose the modelling of intelligent agents for CSCL environments in terms of their capabilities and their mental state, which refers to an explicit representation of the agent's commitments and beliefs [Shoham, 93], [Ayala & Yano, 95b].

We have developed two kinds of intelligent agents for CSCL environments: a mediator agent and a domain agent. Mediator agents play the role of facilitators that support the communication and collaboration of learners, while domain
agents are knowledge sources that provide assistance concerning the appropriate application of knowledge in the domain. We propose that intelligent agents in CSCL environments must make intelligent decisions concerning the application of domain knowledge and the promotion of realistic collaboration possibilities in the group, based on their beliefs about the learner's capabilities, commitments and goals.

2.1 Domain Agents

Domain agents have been designed to support the learners with the application of language patterns and expressions of the Japanese language [Fig. 1]. Under request from the learners, via their mediator agents, the domain agents apply their capabilities, which are:

1. The appropriate application of the grammar rules for the conjugation of adjectives, verbs and their use in more complex language patterns, according to the respective communicative act in a dialogue. Domain agents also present examples of dialogues and correct sentences previously constructed by the group.
2. To make an analysis of the sentences constructed by the learner, by manipulating its set of language patterns and expressions represented in Prolog, providing feedback to the learner about the proper application of domain knowledge and helping the mediator agent in the construction of the learner model [Ayala & Yano, 95b].

![Figure 2: Architecture of the mediator agent.](image)

2.2 Mediator Agents

Based on Shoham's agent oriented programming (AOP) framework for agent modelling in distributed artificial intelligence [Shoham, 93] we have designed our mediator agent in terms of its capabilities and its mental state, which is composed by the agent's beliefs and commitments [Ayala and Yano, 95a]. Mediator agents are deliberative agents [Wooldridge & Jennings, 95], implemented in Prolog with an explicit representation of their capabilities, commitments and beliefs. The architecture of the mediator agent is presented in [Fig. 2].

The mediator agent applies its capabilities according to the commitments it makes to the other agents in the environment and to itself. The mediator agent creates its commitments by reasoning with a set of commitment rules [Shoham, 93]. A commitment rule has a mental condition (the mediator agent's beliefs about the learner's capabilities, commitments, learning goals and collaboration possibilities), a message condition (the received messages from the learner and other mediator and domain agents) and an action, which may be a communicative action (send messages to other agents) or a private action (create and change its commitments and beliefs).
In our learner modeling approach for CSCL environments, based on Vygotsky's theory of social learning [Vygotsky, 78], we represent the learner's actual development level as the set of knowledge elements which the mediator agent believes can be applied by the learner without any assistance. The learner's potential development level is represented by the knowledge used by the learner with the assistance of other learners or the domain agents [Ayala & Yano, 95b]. Vygotsky defined the zone of proximal development as the distance between the actual and the potential development level of the learner [Vygotsky, 78] which is considered the space of knowledge elements with more possibilities to be internalized by the learner.

The learning goals, commitments and tasks in the learner model of the mediator agent (its beliefs about the learner) are represented in terms of the situations in the dialogue (communicative acts) and the knowledge elements (language patterns and expressions) that can be applied in such situations. Considering its beliefs about the learner's capabilities, goals and commitments mediator agents are able to keep the learners' awareness on the environment and promote the collaboration possibilities of the learners in the group by supporting the communication of:

1. the goals of the learners, so they can be aware of the intentions of each other.
2. the learners' commitments, so they know the tasks of the learners and who is going to assist who.
3. the learners' capabilities, so learners will understand who would be able to assist them in a given situation, as well as reflect and locate their own level with respect to the group.
4. the learners' constructions and viewpoints concerning the application of knowledge in the virtual workspace (dialogue under construction).

3. Cooperation Between Software Agents

3.1 Cooperation Between Domain Agents

During the construction of a sentence for the common dialogue a learner can send a request of assistance to the domain agents in the network, via her/his mediator agent which works as a facilitator. Following the corresponding protocol, the mediator agent sends the request to the local domain agent (running in the learner's computer). If it is not capable to respond to the request (the case when the required knowledge is not within its capabilities) then the mediator agent sends requests of assistance to all the other domain agents in the network, collects the diverse answers and present them to the learner.

3.2 Cooperation Between Mediator Agents

Promoting collaboration and learning possibilities means the creation of zones of proximal development [Vygotsky, 78] for the learner in the group. The mediator agent continuously informs any change in its beliefs about the capabilities of its learner. This information is used by the mediator agents in order to construct their beliefs about their learners' assistance and learning possibilities in the current group. We have defined this set as the learner's group-based knowledge frontier (hereafter referred as GBKF) [Ayala & Yano, 95b] which includes:

1. The set of complex domain knowledge elements related by part-of relations to simpler elements believed to be internalized by the learner.
2. The set of domain knowledge elements believed to be already internalized by the rest of the members of the current learning group, but still not believed to be internalized by the learner.

The learner's candidate knowledge for relevant collaboration (hereafter referred as CKRC) consists of the intersection of these two sets. Based on the construction and maintenance of these representations, the mediator agent is able to propose to its learner those learning tasks where knowledge elements of the CKRC or GBKF are applied [Fig. 3]. This results in the enhancement of the learner's assistance possibilities in the group, promoting the creation of zones of proximal development within which s/he can work and learn from more experienced learners in the group. The GBKF and the CKRC play an important role in the belief revision process. Taking into account the similar knowledge development
among members of a community of practice, a set of rules for the learner model revision [Fig. 2], considers that those knowledge elements in the CKRC and the GBKF, which are applied without help, have been internalized [Ayala & Yano, 95c]. The mediator agent decides to stop believing that a knowledge element is internalized when the learner's behavior contradicts such fact and if that knowledge element was not in the CKRC or the GBKF of the learner when it was assumed internalized.

4. Promoting Effective Collaboration

In order to help the learner to reach a relevant commitment the mediator agent proposes to the learner a list of learning tasks based on her/his CKRC and GBKF sets. Then the learner commits to a task for the construction of the dialogue by selecting the knowledge elements to be applied in a situation for the dialogue in which a sentence must be constructed.

The task proposal is presented as a list of knowledge elements, sorted by their degree of feasibility, relevance or popularity, according to the learner's choice. These degrees are calculated based on the part-of relations among knowledge elements and the capabilities of the learners in the current group [Ayala & Yano, 95b]. When the CKRC set of a learner is becoming empty, the mediator agent will believe that the learner's possibilities to commit to a learning task where s/he may obtain assistance and learn from other learners are decreasing. In such a case the mediator agent sends a request of mutual interest task proposal to all mediator agents in the network [Fig. 4], together with its learner's GBKF, asking the other mediator agents to propose to their respective learners those tasks where knowledge elements contained in the GBKF of its learner are applied. As we discuss in the next section, this results in the increment of the knowledge elements of the learner's CKRC, which results in a maintenance of her/his motivation, as well as more
assistance and learning possibilities in the group.

5. Evaluation of the Mediator Agents Performance

We have conducted several simulations, considering 80 heterogeneous groups of four learners (A, B, C and D) who are believed to have 16, 12, 8 and 4 internalized domain knowledge elements respectively, as initial beliefs in their mediator agents' learner models. In order to observe the mediator's performance on behalf of the learners, we supposed that these four learners always commit to the best proposal presented by their mediator agents. During the simulations, each mediator agent proposes a set of learning tasks to their learners, considering the changes in their GBKF and CKRC sets. Each simulated learner selects a task, according to a strategy that defines him, which may be the selection of tasks mainly considering the relevance, feasibility or the popularity of the knowledge elements involved. Each simulation corresponds to a group defined by the selection strategies of its learners and implies 24 tasks selections and the correspondent applications of knowledge elements.

The results indicate that the mediator agents are able to determine a task proposal in reasonable time and support the learners in the navigation through the domain agents’ knowledge bases, while maintaining the collaboration possibilities in the group. As an example, in the worst case obtained in the simulations the two advanced learners A and B and the novice learner D committed to the task considering the popularity of the knowledge elements involved, while learner C selects by considering the relevance. Even in such a case the mediator agents kept the CKRC of the group at an average of 2.28 knowledge elements for each task proposal.

We also simulate the case when we have no-cooperative mediator agents, which result in periods of empty CKRC which represent few possibilities of collaboration [Fig. 5]. When the mediator agents cooperate proposing tasks of mutual interest for the same simulated group [Fig. 6], the number of CKRC elements increased. This is an important issue, since without the cooperation between mediator agents an advanced learner, who usually is playing the role of leader assisting the other learners in the group, would not receive help from any of them, in the case when none of the other learners has successfully applied a knowledge element that this advanced learner has not internalized yet. Then her/his CKRC and GBKF sets may not increase, decreasing her/his learning possibilities and her/his motivation to collaborate.

![Figure 5: Collaboration possibilities in the group without cooperation between mediator agents.](image-url)
6. Collaboration Between Learners

When constructing a sentence in Japanese for the common dialogue a learner can make a request of assistance from other learners in the network, via her/his mediator agent. After consulting the capabilities and commitments in the learner model of a given group member, the learner may decide to send her/him a request of assistance. Also, the learner may ask the mediator agent to send requests of assistance to anybody. In such a case, the mediator agent sends the requests only to the members of the learning group believed to be able to help. A request of assistance consists of the situation in which assistance is needed for the application of domain knowledge and a message (text) explaining additional details for the help needed. During collaborative writing of a dialogue, the mediator agent also allows the learners to discuss the appropriateness of their constructions. When learners disagree about a construction in the dialogue they cooperate constructing a new sentence, discovering the differences between their prior beliefs and alternative applications of domain knowledge in a given situation.

7. Conclusions

In this new phase in the development of GRACILE we have implemented two kinds of software agents: domain agents which are distributed domain knowledge sources that assist the learners in the application of domain knowledge and mediator agents which support the relevant collaboration in the group. The mediator agent is an intelligent software agent designed to support the conditions for effective collaboration between learners in a networked community of practice, proposing to the learner a set of tasks which imply the application of knowledge considered internalized by other learners, as well as feasible, relevant and popular, maintaining her/his collaboration and learning possibilities.

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Tools and Services for Authoring on the Fly

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Abstract

We describe an attempt of automatically transferring a lecture, which is given using the computer instead of an overhead projector, into a multimedia document for offline use. This approach is called authoring-on-the-fly and is very close to the traditional style of lecturing. It facilitates the production of high quality educational material far exceeding the quality of books and audio and video recording of lectures. Moreover, if the MBone whiteboard wb from the MBone toolset is used, it also has the potential of merging different tasks like teaching in class, teleteaching and courseware production together. Experiments using the whiteboard wb from the MBone toolset show, however, that it does not offer enough facilities for the lecturer to support teaching of nontrivial content of any kind, even if one restricts oneself to the area of algorithms and data structures. We have therefore begun to develop a new whiteboard and report about its use for teaching and authoring-on-the-fly.

1 Introduction

Paperbound documents like books, course notes and copies of transparencies, have traditionally supported teaching at university level. Currently available technology of networked computers, however, may open new avenues of supporting lecturing with hypermedia documents. In this paper we describe a new approach of automatically transferring a lecture given using the computer into a multimedia document. This approach of authoring-on-the-fly is close to the traditional style of lecturing, because the lecturer as the content provider can concentrate on how to present a certain topic without depending too much on mastering systems and technology. But it is nevertheless possible to create high quality educational material for off-line use in this way, whereas the quality of presentation is by far superior to a book or a video and audio recording of a lecture.

The key idea is to use the computer as a substitute of the blackboard and overhead projector. So far we have used the whiteboard wb, which is part of the MBone toolset [Eri94]. The actions carried out on the whiteboard by the lecturer were synchronized with digitized versions of audio and video recordings of the lecture. Using wb as an electronic substitute for the blackboard has the advantage that a computer given lecture can be transmitted to remote locations via the Internet, which makes it possible to merge computer presentation, distance teaching, computer conferencing and CAI-authoring.

We have run a number of successful experiments and have demonstrated the feasibility of this approach for carefully selected topics in the area of algorithms and data structures, which belongs to the core of any computer science curriculum. Computer given lectures up to the length of 70 minutes have been broadcasted to different locations in Germany. We have developed new software for postprocessing the recorded data, in particular an external viewer for Hyper-G [KMS93], which synchronizes audio- and video-streams and whiteboard actions. We have linked the postprocessed data together with scientific papers, book chapters and animation- and simulation programs using the linking facilities of Hyper-G.

In this paper, we start by briefly describing the lecturing scenario and the kind of software we have developed and used for producing multimedia documents in this way. As the result we obtain educational material, which can be stored on a server and distributed in local area high speed networks for offline use by students. We have started to produce a series of computer given lectures on ‘Algorithmic Design Principles’ (such as Divide - and - Conquer, Backtracking, Dynamic Programming, Heuristic Search, Randomization, and others). Simultaneously we have developed the tools to automatically transfer the lectures into multimedia documents.

Our approach is similar to the one of [CGJ*94] who have produced multimedia (CD-ROM based) proceedings of scientific conferences. Our approach, however, differs from theirs in several important aspects. We mention in particular: Direct recording of actions carried out on the computer instead of scanned-in slides shown on an overhead projector, possibility of transmission of lectures to remote locations when using wb, use of standard open hypermedia linking tools (Hyper-G), which make it easy to augment the resulting multimedia documents with additional features (glossary, animations, simulations, exercises, bulletin boards etc.) and to make them accessible over information highways.
2 Preparation and delivery of a computer lecture

After selecting a topic the teacher (lecturer, professor) concentrates on the question of how to present the content similar to the traditional way of teaching using an overhead projector. However, instead of drawing transparencies for overhead use he prepares “slides” as computer screens. For that purpose he can use a standard tool (like showcase, Framemaker, \LaTeX), if colored postscript files are paged up and down on the screen. An alternative is to use the computer whiteboard itself in order to prepare slides. Slides should be carefully designed in the sense that they should not contain too much text and can be used as fill-in forms or templates to be completed during the lecture. Note that this requires the lecturer to have some knowledge of the facilities which the (electronic) whiteboard offers him. The slides are then loaded and shown in the whiteboard window. It is assumed that the whiteboard window is either projected to a large screen in a lecture hall or transferred to student computers at the same or at remote locations. (This was the scenario when we used the \textit{wb} of MBone.) The teacher can not only page the slides up and down but can also highlight, mark and draw on the slides. He explains everything like in a standard lecture but uses mouse and keyboard instead of chalk or pen.

The audio and video streams and all actions on the whiteboard are also communicated to the students, either online in the lecture hall or, again using the MBone-tools, to remote locations. Experiments, which we have carried out by transmitting lectures to Munich and Mannheim from Freiburg show that the delay-free transmission of the audio streams and of the whiteboard actions is much more important than the continuous transmission of the video stream of the teacher. This means that it is acceptable to ‘freeze’ the picture of the lecturer as long as the audio stream and the whiteboard actions arrive almost synchronously at the remote location. Though the Internet was not designed for guaranteeing a continuous data transmission with a given bandwidth, our experiments have demonstrated that even a small data transmission rate (e.g., 128 Kb/sec) is sufficient to obtain acceptable quality at the receivers location. This implies that it is currently not the small bandwidth of the transmission, which is the most serious drawback for a good computer lecture given in this way, but the rather limited features of the whiteboard \textit{wb} of the MBone toolset. Of course \textit{wb} of MBone was not designed for the purpose for which we have used it. Therefore, we have begun both to gradually enlarge the features of \textit{wb} and to develop our own whiteboard with enhanced facilities. These can be used more comfortably by the teacher to deliver lectures on the computer, which are then turned into multimedia documents for offline use (see section 4).

3 Transferring a computer given lecture into a multimedia document

The raw data of a digitized computer lecture consist of the stream of whiteboard actions, the digitized audio stream and (if desired) the digitized video stream. We recommend to make a S-VHS recording of the lecture and to digitize it with SGI capture tools afterwards. Using these tools, we can either produce an AIFC audio file (using audio only) or a SGI movie. This is actually a non standard format but it will soon be extended to include the MPEG-I system format. If the MBone whiteboard is used, the whiteboard actions are recorded with our multicast recorder (MCASTREC\footnote{available under ftp://ftp.informatik.uni-freiburg.de/pub/AOF}), which transforms the whiteboard actions into a readable format.

We have implemented a viewer (SYNCVIEW\footnote{see 1.}), which replays the movie or audio stream and synchronizes them with the actions on the whiteboard. This viewer allows to scroll back and forth (while following what happens on the whiteboard) and to be started at every frame of the movie or every millisecond of the audio stream. SYNCVIEW can thus be used as an external viewer for Hyper-G. The main reason for choosing Hyper-G as a linking tool was that it makes it easy to use locations in postscript files as anchors for links. If, for example, a student reads a paper (with the postscript viewer of Hyper-G) with embedded links to a corresponding lecture, he can jump to those points in the lecture, which might aid the understanding of certain parts of the paper. If necessary he can select the information he wants by scrolling back or forth. (This situation is shown in figure 1.)

In order to make this possible, it is necessary that the viewer displays always the objects visible at a given point in time on the whiteboard. A simple recording of the data stream generated by the MBone whiteboard does not fulfill this requirement. Think, for example, of messages like “delete object A”, where object A was drawn a long time ago.

But if we postprocess the whole lecture, we can transform the whiteboard stream to a desirable format. We compute an object list each time a change of (graphical, textual, ...) objects occured on the whiteboard. Hence, we
can attach to each point in time a display list, which contains exactly all the objects accumulated on the whiteboard until the respective point in time.

Thus, our set of software tools is sufficient to transfer a lecture 'on-the-fly' into a hypermedia document, if the whiteboard $wb$ of the MBone-toolset is used. However, our experience shows that $wb$ does not offer enough features to the lecturer in order to prepare and deliver nontrivial content of any kind, even if one restricts oneself to the area of algorithms and data structures. In fact, the $wb$ has simple drawing facilities for drawing freestyle lines, straight lines, arrows, rectangles and ellipses. It is possible to erase and move objects. But $wb$ does not allow to group graphical objects, to control an animation from the whiteboard, to zoom-in-and-out, etc.

4 The enhanced whiteboard

We want to use the computer screen, or more precisely, a small number of windows on the screen as an electronic substitute for the blackboard and the overhead projector. Because $wb$ turned out to be insufficient for our purposes, we have started to develop our own whiteboard\(^3\). Note that enhancing the facilities of the whiteboard implies

\(^3\)available under ftp://ftp.informatik.uni-freiburg.de/pub/AOF
that simultaneously the viewer software for computer given lectures has to be enhanced also. Note that giving up wb in favour of our own whiteboard has the consequence that the multicast facility of wb is lost. However, the data stream generated by using our own whiteboard can still be interpreted by our viewer software; hence, the authoring-on-the-fly facility is maintained. Because the wb code is not public domain we had to start from scratch in order to develop a new whiteboard. So far the following editing and control facilities have been implemented into our own whiteboard (see also Fig. 2):

1. Editing of text including cursor-, delete-, insert operations.
2. Drawing of graphical objects like lines, rectangles, circles, freehand etc.
3. Loading, presenting of image data in various formats (jpg, gif, tiff, rgb, postscript).
4. Modifying of graphic or text objects.
5. Selecting and Grouping of graphic or text objects.
6. Move/copy/push/pop objects or object groups/selections.
7. Zooming-in, zooming-out, s.t. the relative distances between objects are preserved.
8. Pre-development of objects/pages which can be reloaded and modified during a session.
9. Preview pre-developed pages/objects before presenting.
10. Replacing selected objects with pre-developed objects.
11. Launching applications (e.g. animations).
12. Recording audio directly in order to replay the session immediately after it was given.
13. Edit a \LaTeX{}-segment (i.e. a mathematical formula) and inserting it as image data.

Note, that these features by far exceed the facilities of \textit{wb}. Let us discuss a few features in some more detail:

Feature 1 enhances the weak text editing facilities of the MBone whiteboard. Note that all actions during an editing session (except cursor operations) are recorded and, therefore, part of the replay.

Pre-developed screens can be overlayed in order to simulate the overlaying of transparent slides on an overhead projector; they can also replace selected objects, which are currently shown on the screen. These pages can be previewed and then overlayed with a simple double mouse click.

The problem of how to launch and control an application has not been solved completely yet. So far we restrict ourselves to applications with the following properties:

1. The application opens a new window and starts running immediately.
2. No interaction can change the behaviour of the application.
3. The application stops running automatically (and destroys its window).

Assuming that an application fulfills these properties we may expect that during a replay of the session the synchronization of speech and the graphical output of the application is preserved.

It is well known that a mathematical derivation (like the development of an algebraic transformation) is optimally explained if each step is slowly written (by hand) and commented by the lecturer. Because writing on the screen by the mouse or keyboard is not as easy for a lecturer, it is still open how we can provide a lecturer with a good facility to slowly develop and comment mathematical formulas on the screen. So far we experimented with \LaTeX{}-input (feature 13) prepared by the lecturer prior to the lecture and then loaded to the drawing surface line by line, but we plan to test other input devices such as electronic pencils etc..

Ideas of what other features an electronic substitute of a blackboard should have could also be borrowed from [LH94].

Our aim is, simultaneously to enhance the whiteboard and to use the respective new facilities to prepare a more demanding lecture on a new topic (from the list of topics mentioned above). This gives us direct feedback of how well the facilities of the whiteboard are suited to support lecturing, that is, we show what features are necessary, respectively, optimal for the topics we considered (algorithms and data structures, in particular: algorithm design principles).

5 Conclusion and further work

The ultimate aim of our effort is to obtain a multimedia document on the fly with the audio-, video- and whiteboard recording of a lecture, a scientific paper (book chapter, journal paper), animations, simulations (learner controlled), questions, glossary, table of contents, etc. These different parts are linked together using the linking facilities of Hyper-G.

Currently available MBone-recorders are not sufficient to produce a multimedia document useful for offline use. They simply record all data transmitted over the net and allow a replay from the very beginning. Our aim, however, is to enable the user to jump to a specific point in time of the lecture and to display precisely what was accumulated on the whiteboard. As mentioned above, if we use the MBone whiteboard, this requires a postprocessing step, which attaches to each point in time a display list containing exactly all the objects accumulated on the whiteboard during the respective instance of time. This allows scrolling back and forth in the recorded lecture, always displaying the correct situation on the whiteboard.
It should be clear that the inclusion of new features into an enhanced whiteboard may imply an extension of the viewer as well. We want to mention two basic enhancements of our whiteboard, which can be useful in future:

- Providing the enhanced whiteboard with a multicast facility s.t. it can be used for teleteaching as well. Note that this implies the implementation of a transmission protocol and of a viewer for the receiver.
- Inclusion of a HTML3.0 formatter for presenting HTML-documents. This will be the key for using large distributed electronic libraries (e.g. WWW or Hyper-G based) as source for online teaching.

It may also be desirable to edit the recorded material; for example, the lecturer wants to cut out pauses or mistakes, and he may want to merge material from different lectures. Current editors for audio- and video-streams are, obviously, not sufficient for this task (because one has to pay attention to the whiteboard stream, too). We have begun to implement an appropriate editor concurrently with the enhanced whiteboard.

References


"What’s IS All About?": A Multimedia Aid for Learning Information Systems (IS) Concepts and Methodologies

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Abstract: "What's IS (Information Systems) All About?" is an educational multimedia program to help business students learn about information systems concepts and methodologies. This system is the result of a University Teaching Center grant at George Washington University. This application is quite novel, and uses a "mystery" metaphor to engage the student in understanding the problem solving steps in information systems development.

Introduction

Recently, there has been increased interest among educators and employers in the enormous potential for computer-based training and education to improve classroom learning [Reinhardt 1995]. Many empirical studies have shown that computer-based training and education enhances the students' learning and ability to apply knowledge and skills to real problem-solving situations [Bland 1995; Alavi 1994; Leidner & Jarvenpaa 1993]. Various information technologies, such as networking (LANS and Internet), multimedia, and groupware, are fueling the new wave of better learning tools. In particular, interactive multimedia becomes a mainstream learning technology in all levels of education as a result of the rapid growth in the availability and accessibility of multimedia-equipped computers. Education experts predict that professionally produced multimedia programs will soon emerge as supplements to traditional textbooks [Topping 1994]. Today's powerful and easy-to-use multimedia authoring tools allow educators to develop their own instructional multimedia programs. The power of interactive multimedia in supporting the learning process is in the ability to combine various forms of information (text, audio, and visual), and provide interactive functionality for students to navigate for information on their own path and pace. Therefore, interactive multimedia is more useful in the education programs in which students have widely varying knowledge/skill levels, students' own participation is essential to effective learning, and educational material is very complex to present at the classroom.

In the past, the educational use of interactive multimedia has concentrated on teaching factual materials, and neglected such cognitive skill teaching as problem solving, reasoning, management, and analysis skills. Recently, many universities and companies are developing interactive multimedia training/education programs for the cognitive skill learning. Harvard Business School pressed a CD-ROM based multimedia courseware, called "Managing International Business", for global strategy management education. The George Washington University developed a multimedia expert system, called "the Protocol Multimedia Expert System (PMES)", for cross-cultural training [Liebowitz et al. 1995]. Andersen Consulting, an international management and technology consulting firm, also developed several multimedia training programs for teaching basic business functions, such as sales and marketing, cash management, order management, etc. [Acovelli & Nowakowski 1994]. Where the instructional content revolves around problem solving, reasoning, analysis, and management, more opportunity for multimedia use might result when the instructional content focuses on facts. The impact of multimedia use on student learning is also greater in cognitive skill learning than in factual learning, because there are great advantages to providing students with many perspectives on the same body of information in teaching the cognitive skills. An empirical study shows that multimedia training can teach students cognitive skills up to 15 times faster than the traditional training [Johnson & Wiegner 1992]. The subsequent impact increases if the instructional content of the course should deal with both factual information and the cognitive skills. This kind of course content creates a more complex learning environment because its depth is so deep and its width is so broad. Information Systems (IS) education can be an example.
In this paper, we will examine the problems associated with traditional IS education and the possible use of interactive multimedia to supplement the traditional IS education, and introduce an interactive multimedia training application for IS education, called "What's IS (Information Systems) All About?". We hope that our study provides meaningful guidelines to IS faculty and the IS profession who want to develop instructional/learning modules using interactive multimedia for classroom use in IS.

Information Systems (IS) Pedagogical Issues

IS itself is for most students one of the most familiar terminologies. However, the definition of IS varies from school to school, from textbook to textbook, from professor to professor. There is also a strong debate on topics to cover and format of the class in the IS community. The facts reflect how difficult it is to teach students information systems.

Our definition of IS is that IS is not just the software and the hardware; IS consists of people, procedures, data, software, and hardware [Jordan, et al. 1990]. Under the definition, IS people are responsible for defining new information system needs of the various managerial levels of the organization, as well as developing new information systems. Therefore, students seeking long-term careers in IS have to learn both cognitive and technical skills.

Since the scope of IS education is broad and the level of IS education varies, one of the key concerns of IS pedagogy is providing all technical and cognitive skills needed in analyzing, designing, and implementing IS according to student competency. Traditionally, when teaching the subject of IS, the instructor has had to use either a textbook or to develop his/her own teaching notes. Some instructors supplement the traditional teaching methods by using the case study or audio/visual tapes. However, these teaching methods are not enough to supporting the dynamic, multi-disciplinary education for IS. The most effective learning for IS takes place through a student's own experience and discovery. This learning allows students to develop their ability to deal with complex, ambiguous situations, to determine their own decisions and action plan, and to defend their idea. Schank [1994] calls this kind of learning "active learning", and he says that interactive multimedia training enhances the learning by allowing students to go back over a subject or fast-forward over an area that they understand or do not need. The students can go through the whole course, or just cover essential sections. The flexibility enhances a student's participation and helps a student build his/her own knowledge.

Case Study: “What’s IS All About?”

Interactive multimedia technology has emerged as a major technology in IS, but the educational use of the technology in the discipline of IS is still in its infancy. Many prior multimedia applications have been developed in the area of children education [Armstrong et al. 1994]. However, recent rapid changes in IS technologies, applications, and management require students and employees to have a different set of skills than those emphasized in early twentieth-century IS pedagogy. Many companies and universities are being forced to invent more efficient ways of delivering the new knowledge to keep their students and employees up with the changes.

At the George Washington University (GWU), an educational multimedia program, called KARTT (Knowledge Acquisition Research and Teaching Tool), is developed for teaching knowledge acquisition skills [Bland 1995]. James Madison University (JMU) developed an interactive tutorial package, called "Developing Your First Expert System", to help students understand the basic concepts of expert systems [International Society of Intelligent Systems 1995]. And Mississippi State University (MSU) launched a big project for the development and implementation of computer-based multimedia instructional materials in the IS classroom [Shim et al. 1994]. Besides these universities, many other universities also actively involved in developing multimedia training programs for their students. One company that has begun to harness the power of multimedia for training its worldwide staff is Andersen Consulting. Recently, Andersen Consulting developed the object modeling system, which is designed to help consultants understand the basic concepts of object-oriented programming [Jordahl 1995]. Based on these examples, we can predict that multimedia will play an increasingly larger role in both the university education and the corporation training for IS.

We developed a multimedia program for IS education, named "What's IS All about?", which is designed to integrate the various course materials, to foster the student's analytical and problem solving skills, and to help the student acquire the big picture of IS. Its three objectives can be accomplished by providing students with many perspectives on the same body of information. Experiencing complex material repeatedly under different contexts provides multiple opportunities to gain a deep understanding of the subject [Sprio & Feltovich 1991]. Our multimedia program provides different views of IS by allowing students to explore various IS methodologies and
case studies, and practice their analytical and problem skills. We believe that it helps students and employees acquire the skills for tomorrow’s IS professionals. The multimedia program is developed through a University Teaching Center award at the GWU. It currently has two learning modules—one for a general introduction to IS, and the second for understanding the information systems development steps (via a mystery). We are currently in the process of adding four other learning modules (Information Engineering, Object-Oriented Programming/Design, Rapid Prototyping, and the Waterfall Model).

Analysis

The goal of traditional system analysis is to understand a complex system well enough to extend or enhance its functionality to improve efficiently. In the case of educational multimedia system design, the goal is to understand the learning system of the user. The quality of an educational multimedia system is heavily dependent on the system's ability to emulate the user's natural learning system. System analysis in designing the educational multimedia system starts with identifying the target audience. By identifying the target audience, we can specify learning requirements for the target audience; that is, the core skills and learning points around which our multimedia system will be constructed.

Our multimedia system is primarily designed for the introductory courses to IS in both undergraduate and graduate levels at the business school. Therefore, our primary target audience are both business undergraduate and graduate students who are taking these IS courses. We assume that most of them have very limited exposure to IS and that some of them are perhaps computer illiterate. Companies also can use our multimedia system to keep their employees on the cutting edge of the Information Age. Today's competitive business environment requires companies to educate non-IS employees for IS. By using our multimedia system, companies could hopefully increase education effectiveness and lower education cost.

Since our target audience are novices to IS, instruction of our system should focus on delivering basic knowledge, rather than higher-level knowledge. And we need to help the audience learn how to apply important knowledge and expertise to new and unknown situations. Finally, the content of our system should balance technical and managerial knowledge. The need for people with both technical and managerial competence is increasing while most forecasts state that the shortage of people with these skills will increase in the foreseeable future. When our program satisfies the need, it can gain more student's attention, thereby increase educational effectiveness.

Design

In this step, our purpose is on designing a learning environment that is flexible enough to accommodate the multiple, unpredictable approaches learners may take while they navigate information. There are several user interface design guidelines to achieve the purpose.

Maintain Consistency

The basic purpose of consistency is to allow the user to generalize knowledge about one aspect of the system to other aspects. Examples of consistency include using the same color to code information in the same way and placing of menu items in the same position within a menu. In our system, we link green underlined words to hypertext in order to maintain the consistency with color and font of hypertext in Windows Help.

Our system currently has five different types of screens (tutorial sessions, case studies, workshop for problem-solving, exercises, and hypertext). Each class of screens maintains the same background to ensure consistency. The consistency provides the user with feeling about where he/she is in the system. But, we use the same navigation buttons throughout all screens to prevent the user from spending time learning the usage of different types of the navigation buttons.

Accommodate Multiple Skill Levels

Our system should be addressing all levels of student competency, because IS education entails a trade-off between keeping the brightest students interested and risking losing the attention of those who cannot keep up with the material. The system has three layers of knowledge: the basics of IS, problem solving workshop, and IS development methodologies. The user can choose either one depending on his/her interest or ability.

Use Proper Metaphor
People develop new cognitive structures by metaphorically extending what they already know or are familiar with. The use of metaphor is a very effective way of teaching higher-level cognitive skills. Although people go through new cognitive skills, they cannot gain deep understanding and apply the learned skills to new and unfamiliar situations. In our system, we choose the mystery novel as a metaphor to teach problem solving skills in IS methodologies. Since many are familiar with the mystery novel, and the detective's problem solving steps in a mystery novel is similar to the ones used in IS methodologies, the metaphor will help users to understand the steps easily.

Based on the guidelines, we write storyboards to specify screen layouts.

<table>
<thead>
<tr>
<th>Name:</th>
<th>DefInfo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose:</td>
<td>Definition of Information Systems</td>
</tr>
<tr>
<td></td>
<td>Definition of Information Systems (Text)</td>
</tr>
<tr>
<td></td>
<td>Background Music (Audio)</td>
</tr>
<tr>
<td></td>
<td>Toyota Case (Video)</td>
</tr>
</tbody>
</table>

Figure 1: Higher Level Storyboard
Develop

Step three is development, in which we build our multimedia system. In this step, we develop more detailed storyboards and encode the storyboards with the authoring system.

![Storyboard](image)

<table>
<thead>
<tr>
<th>Frame Name: InfoDef</th>
<th>Frame Type: Lesson Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navigation Tool: All_Grey</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Storyboard

Authoring systems are software tools that enable educators to create the interactive multimedia courseware without involving programming works, thereby allowing those who lack either access to programmers, time to program, or interest in learning programming to quickly produce courseware to supplement their classroom activities [Locatis et al. 1992]. There are currently many computer-based training (CBT) authoring tools on the market. We chose CBT Express of AimTech as an authoring system for our multimedia courseware development. While most authoring systems automate only coding, CBT Express goes much further by using templates to automate screen design. It allows us to concentrate on the educational aspects, not on the technological aspects, of the courseware being designed.

Future Work

First, we should enrich the current version of "What's IS All About?" by adding more modules. We are currently adding four other learning modules to the system: namely, modules describing the waterfall model, information engineering, object-oriented programming/design, and rapid prototyping. Each module consists of general introduction, case studies, and exercises for each methodology. These modules will be linked with "What's IS All About?"

Second, we need to evaluate the educational effectiveness of "What's IS All About?" by conducting an experimental study. This would be accomplished once the other modules are incorporated into the multimedia aid.

References


Interface Design to Support Active Learning

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Abstract: Increasingly, computer-based systems are being used for the storage and dissemination of multimedia learning and training resources. The movement from paper-based to electronic storage and delivery provides a number of advantages but also presents some interesting challenges. These challenges arise from a variety of issues - relating to resource utilisation, organisational infrastructure and end-user interface design to support information access and retrieval. As part of an ongoing project into the design and development of performance support systems for use within academic environments, we have been exploring the use of multimedia and hypermedia techniques. Of particular importance is the requirements that these facilities place on the design of end-user interfaces. This paper therefore discusses some of the issues that need to be addressed when designing interfaces to support active learning within multimedia environments.

1. Introduction

The design and creation of multimedia and hypermedia learning resources are expensive, complex and time consuming tasks. It is therefore important to base the production of such materials on sound and well-founded models. It is also imperative that proven techniques and methodologies are employed in order to produce 'quality' learning products that stimulate and motivate their users. These products should also foster the development of rich and relevant cognitive structures relating to the particular domains of study in which students become involved. Our vision of the relationship between learning environments, learning activities and the development of cognitive structures (and their influence on behaviour) has been discussed in detail in [Barker, 1995a]. Within this discussion it is suggested that learning normally occurs as a consequence of the various environments and experiences (or 'learning encounters') to which individuals are exposed. These primitive learning encounters fall into two broad categories: natural and contrived. Natural encounters arise as a consequence of the normal course of events in which individuals become involved. In contrast, contrived encounters are those that have been designed and 'put into place' by cognitive systems engineers in order to support some form of learning or training process.

Naturally, the use of interactive multimedia and hypermedia techniques for the creation of learning environments necessitates the use of a computer system both for the development of learning resources and for their subsequent delivery. Two important factors that influence the quality of the resulting products are: (1) the medium upon which they are published; and (2) the types of end-user interface that are employed in order to facilitate human-computer interaction within the interactive learning environments that are produced.

From the perspective of human-computer interface design to promote and support active learning, the important problems that have to be addressed are: (1) deciding how experiences that are embedded within some form of computer-based system can best be presented to learners/trainees; (2) deciding how human-computer interfaces can be used to initiate, promote and sustain involvement in computer-based learning activities; and (3) designing interfaces in a way that enables the maximum pedagogic impact of the underlying computer system to be achieved. These are the basic issues with which subsequent parts of this paper will deal.

2. Generic Tools To Support Electronic Learning

In order to make learning and training with computer-based systems as effective and efficient as is possible, a range of different types of 'support tool' is needed. These support tools may be of two basic types: application-oriented and generic. The first of these types of tool will depend heavily upon the nature of the subject domain with which the courseware deals. The second type of tool is of a more general-purpose nature; tools in this
category can be used in almost any learning/training situation. This paper is only concerned with generic tools. Six basic types of tool are considered - tools to support retrieval, coaching, visualisation, discussion and debate, assessment and personal learning activities. Some consideration is also given to integrated toolsets similar to those that are encountered in performance support systems [Banerji, 1995; Barker, 1995b; 1995c].

2.1 Retrieval Tools

Increasingly, computer-based learning resources are being organised and made available to users by means of some form of 'digital electronic library' facility. Libraries of this sort are usually made up of various types of document that are 'published' in one or other of two basic ways. First, as relatively static publications on a medium such as compact disc. Second, as dynamic ('living') publications that are accessed through a computer communications network such as the Internet. No matter which type of publication medium is used, it is important to make available appropriately designed search facilities to enable potential users of learning resources to retrieve and use them and/or browse through the materials in a serendipitous way.

2.2 Coaching Tools

In order to reinforce basic skill acquisition suitably designed 'coaching software' often has to be employed. Such software facilitates skill improvement through the use of appropriately designed coaching tools. These tools can be used to enhance both mental and physical performance. In many cases the tools that are used for coaching embed models of 'expert' behaviour; these are used to guide the instructional activity. In many ways they are therefore similar to intelligent tutoring systems. Coaching tools can be incorporated into an electronic learning environment in two basic ways: either as a stand-alone item or as an embedded facility within some other courseware item or software product. In the latter case, some form of built-in intelligence (such as an 'intelligent agent') can be used to monitor how a product is being used and the levels of performance that are being achieved. The coaching facility can then be automatically invoked when performance levels fall below those which are expected.

2.3 Visualisation Tools

A visualisation tool is essentially a facility that enables students and trainees to obtain particular perspectives on and views of a collection of stored data or of a dynamic, ongoing process. Such tools are usually highly interactive since they allow their users to have both fine-grained and coarse-grained control over the view or system perspective that is presented. Visualisation tools vary quite considerably in their power and potential depending upon who they are intended for and what they are intended to do. An important aspect of visualisation tools is their ability to use the available display and interaction technologies (sonic, visual and tactile) to maximum effect in order to enable their users to develop appropriate models of what is happening within hidden or difficult to perceive processes. These processes may be as simple as text editing or as complex as bridge building or non-invasive surgery (possibly undertaken remotely using telemedicine techniques). The design of visualisation tools will usually involve the use of graphical user interfaces, pictorial interface systems and interactive multimedia techniques.

2.4 Discussion and Debate

An important aspect of learning is the ability to talk with other people (either formally or informally) about the material and concepts that are to be learned. Learners may wish to discuss and debate various topics and issues both with fellow students and with staff tutors. In order to meet this requirement within an electronic learning environment it is necessary to provide a range of interactive communication tools to support both individual and group communication processes. The most common types of tool in current use are electronic mail, bulletin boards and various forms of computer conferencing software. Electronic bulletin boards provide a 'one-way' communication facility that enables an individual to make information available to others - either publicly or in a closed group. On the other hand, electronic mail provides two-way communication between individuals or an individual and a group. Computer conferencing facilities enable various sorts of 'forum' to be created in which participants can exchange views and ideas on various topics.
2.5 Assessment Tools

One of the most attractive features of computer-based approaches to teaching and learning is the potential it offers for providing monitoring and feedback. Monitoring processes are used for three basic purposes: first, to enable courseware to adapt its behaviour to the needs of specific individuals and situations; second, to provide a source of assessment data which can be used to derive performance indicators for students and trainees; and third, to provide a basis for the generation of feedback information. Monitoring and assessment techniques can be embedded within courseware packages or they can be made available as stand-alone assessment tools for use in a formal or informal way by students.

2.6 Personal Tools

The use of computer-based, interactive workstations to facilitate learning and training processes is becoming increasingly popular in a wide variety of different contexts. Obviously, in order to facilitate effective and efficient instruction, the workstations that are used must provide access to a wide range of different kinds of support tool for personal use. These support tools must enable students and trainees to use the available instructional resources in ways that are appropriate to each individual's needs and situation. The personal tools that are usually made available in a workstation environment fall into two basic categories: general purpose and application specific. Typical examples of general purpose tools are items such as a calculator, a timer, a notepad, dictionaries of various sorts, personalised spell-checkers, and so on. Some examples of application oriented tools include pronunciation packages (to support language teaching courseware) and subject-specific databases to facilitate the retrieval of information within particular learning domains.

2.7 Integrated Toolsets

Electronic problem solving tools form an important part of an interactive learning environment. These tools can be integrated and packaged in various ways in order to meet the needs of particular applications. The basic rationale underlying our own use of integrated toolsets within a workstation environment stems from the research that we have been undertaking within the area of electronic performance support [Barker, 1995b; 1995c; Banerji, 1995]. In this work we have defined a four-layer model for the creation of workstation services. The four levels deal with: the end-user interface; the selection and creation of generic tools; the selection and creation of application specific tools; and the application itself. Obviously, toolset design has to accommodate two different perspectives: the needs of the user and the requirements of the target application domain. The issues dealt with in the application layer relate to the way in which the target domain has to be restructured and reorganised in order to accommodate the introduction of electronic performance techniques.

Within the four-layered framework described above, end-user interface design has two critical roles to play. First, it must ensure that the interfaces used within the different toolsets are consistent and compatible with each other. Second, it must integrate the various toolsets together in the most appropriate way possible - so that end-users are exposed to a single uniform set of end-user interface standards. Some of the more important aspects of interface design needed to realise these goals are discussed in the following section.

3. Interface Design Issues

The issues that are involved are often very complex. This section therefore briefly discusses some of the more important facets of interface provision. The topics covered include: interactivity; the role of metaphors; the use of graphical user interfaces (GUIs); interface standards; the use of multimedia, hypermedia and multiple modality; providing support for collaborative learning; and help facilities.

3.1 Interactivity

The term interactivity refers to the various changes of state that take place within a human-computer system as a consequence of ongoing dialogue processes. Such processes have two basic functions: first, to facilitate basic information exchange between the dialogue partners; second, to provide a mechanism for control activity and the
shifting of its focus. Undoubtedly, one of the most important issues that has to be considered when designing an end-user interface to a courseware product is the level of interactivity that it should embed. Low interactivity in a learning product often reflects a high degree of passiveness with respect to the decision making processes involved in controlling courseware activity. A good 'rule of thumb' is to make courseware as interactive as possible - as this often engages students and can result in high levels of motivation.

3.2 The Role of Metaphors

The importance of metaphors stems from their ability to act as 'cognitive transfer agents'. That is, they can be used to facilitate the use of mental models, knowledge and skills that are relevant to one (familiar) area of discourse to be used within another less familiar one [Barker, 1995a]. The classic example of a metaphor that is widely used within many human-computer interfaces is the 'desktop'. This metaphor likens the objects that appear on a computer screen to the familiar everyday objects that reside on (or near to) an office desk - such as a notepad, card-file, address book, filing cabinet, and so on.

Naturally, all metaphors will have limitations. It is therefore important to ensure that any given metaphor is not used outside of its scope. Of course, the shortcomings of a single metaphor can often be overcome by the use of an appropriately designed system of multiple, inter-related metaphors. An arrangement of this sort is often called a 'mixed metaphor' system. Within such an framework, the limitations of one metaphor can thus be compensated for by the use of another closely related one. Obviously, when using systems of this sort it is important to ensure that the constituent metaphors integrate together smoothly and consistently and, whenever possible, reinforce each other in terms of the mental models and cognitive structures that they trigger and/or initiate.

Undoubtedly, metaphors can provide powerful mechanisms which will accommodate both the design and subsequent use of interactive learning and training environments. Furthermore, end-user interfaces that embed appropriately designed mixed metaphors can be used to stimulate and foster the creation and development of rich mental models that will facilitate active learning and problem solving behaviour.

3.3 Use of GUIs

The advent of computer display screens that support high-resolution, multi-coloured images and text has permitted the development of many new approaches to end-user interface design. Currently, one of the most popular types of interface is that which involves multimodal (keyboard and mouse) interaction with one or more graphical images that are displayed on a computer screen. Such interfaces employ conventional menus, windows, dialogue boxes, reactive pictorial elements (for example, icons, picons, micons and image segments), scroll bars and sound effects in order to achieve an efficient, effective and easy to use graphical user interface. There is significant evidence in the literature to support the view that GUI interfaces are much more usable than the conventional command line interfaces that were previously used to control computer systems. For this reason, GUIs should therefore be embedded within courseware products whenever their use is deemed to be necessary or appropriate.

3.4 Interface Standards

An important property of a human-computer interface is its 'look and feel' - that is, how it appears and responds to end-users. For any given courseware application, once the attributes that make up the required look and feel have been decided upon, it is necessary to apply them in a consistent fashion throughout that application - and, if possible, from one application to another. The adoption of a strategy such as this means that the overheads involved in learning the details of an interface can be minimised and experience gained with one learning package can be transferred across to others. A consistent 'look and feel' within an interface can usually be achieved through the imposition of interface 'standards'. Such standards may be formal or informal; they may be in-house, international or de facto. Invariably, interface standards usually embody a wide range of good 'working practice' and commonly agreed upon methods and techniques - the application of which will provide a level of quality assurance within an interface.

3.5 Multimedia, Hypermedia and Multiple Modality
Reference was made above to the importance of graphical user interfaces within interactive computer systems. When used in a learning situation, such interfaces can incorporate text, pictures, sound, animations and motion video in order to achieve the most effective multimedia learning encounter. Obviously, the media mix that is used in any given situation will depend critically upon the topic that is being presented, the way it is to be taught, the learning styles that need to be accommodated and any cost limitations that may be imposed on the courseware.

The instructional resources used in a multimedia learning transaction are often presented in a strictly linear fashion. Of course, there are many learning situations where a non-linear (or hypermedia) arrangement of material would be more appropriate [Barker, 1993]. In cases such as this, the learning resources must employ interfaces that embed appropriately designed reactive areas that enable links to related resources to be explored. The way in which this can be achieved is illustrated in a recent multinational European project entitled 'Hypermedia for Teaching'. This project produced a very 'rich' hypermedia knowledge corpus that was published on CD-ROM and then made available in six different European languages [Barker and Bartolome, 1994].

The use of multimedia and hypermedia interfaces within interactive workstations poses another important issue - that of designing the most appropriate way to facilitate end-user interaction with courseware products. Invariably, some of the most efficient and effective end-user interfaces in current use are those which are multimodal in nature. Interfaces of this type provide users with a variety of interaction mechanisms and input modalities (tactile, gestural, sonic, and so on) in order to facilitate flexible and dynamic approaches to information selection and presentation. Some of the best examples of very powerful multimodal interfaces can be found embedded within courseware systems that employ virtual reality techniques and/or support collaborative learning at a distance [Barker, 1994; Benford et al, 1994].

### 3.6 Supporting Collaboration

In the past, most courseware packages for the support of learning and training have been designed to support individual, isolated users working on their own personal computer systems each of which was located at a particular location. End-user interface design to facilitate this mode of working is fairly straightforward; the various approaches that have been used are well-documented in the literature. Nowadays, the availability of high-bandwidth communication links now makes it possible to devise many different types of 'collaborative learning at a distance'. Within such systems, learners and trainees form distributed learning groups and communicate with each other using interactive workstations that are connected together using various telecommunications networks. All information exchange between learners (and tutors) therefore takes place through the medium of computers. The software used in such systems must support four basic requirements: (1) the creation of a shared virtual learning space; (2) the design of interfaces to communicate with and manipulate shared objects within that learning space; (3) the provision of mechanisms to support inter-personal communication between group members; and (4) the implementation of monitoring and assessment processes which enable each learner's progress to be monitored within the context of overall group progress. Interface design to support collaborative learning is quite complex and currently little understood. There is therefore considerable scope for future developments in this area.

### 3.7 Help Facilities

An important aspect of interface design to support learning and training activity is the provision of any ancillary information that is needed to perform pedagogic tasks in an efficient and effective way [Banerji, 1995; Barker, 1995b; 1995c]. One of the most popular ways of fulfilling this requirement is through the provision of on-line help facilities. Typical examples of this type of facility can be found in most Microsoft products that run within the environment provided by a multimedia personal computer. Examples of such products include Word for Windows, the Excel spreadsheet package and ToolBook [Barker, 1993]. Help facilities can take a variety of different forms - such as an on-line manual (which may be organised in either a linear or a non-linear way), cue cards, prompt sequences, wizards, and so on. Some of the important ways of providing on-line help have been reviewed and compared by Banerji in his research into electronic performance support systems [Banerji, 1995]. Because of the importance of on-line help, considerable effort should be devoted to its design and the way in which it should be made available to end-users. From the interface design perspective the provision of on-line help requires two issues to be resolved: first, how users access it from within the primary task domain in which
they are operating; and second, the nature of the access mechanisms that will be available to them when they are working within the help system itself.

4. Conclusion

Many organisations are now making increasing use of computers as support aids for teaching, learning and training processes. Invariably, the successful deployment of computer systems in these pedagogic situations depends critically upon the use of appropriately designed instructional software. Within such software the importance of end-user interfaces is paramount since it is the interface subsystem that provides the basic mechanisms by which all human-computer information is exchanged. If these interfaces are not to mask or stifle the pedagogic processes they are intended to promote, they must be relatively easy to use, unconstraining and supportive of the tasks that are to be undertaken within the given learning/training domain. End-user interfaces for courseware must also be motivating and helpful with respect to providing advice and feedback relating to the pedagogic matters and procedural issues involved in using an interface. A primary requirement of the courseware that is used in an instructional system is its ability to create, enhance and stimulate appropriate cognitive structures for use in given task situations - as determined by the external cues that are embedded within the environments and situations in which people find themselves. This paper has considered some of the more important issues that need to be taken into account when designing end-user interfaces for use in instructional software - given that its ultimate goal is to develop rich cognitive structures that can handle demanding real-life situations.

5. References

Abstract: This paper studies the quality control during the production of educational multimedia programmes in North America as well as the end users involvement in the development process. A small sample -26 sites- limits the scope of the results that show a high participation of end-users, mainly in the evaluation of product during and at the end of the process. However, continuous evaluation during the production of the programme and participation of users was not generalizable to all of the projects. Other results related to the use of multimedia elements, development tools, costs and people involved have been included.

1. Introduction

Over the past several years we have taught about the use of computers in Education and we have been involved in the production of educational software. An issue that arises frequently is identifying the best way of producing multimedia programmes. Our students and developers like clear recipes or prescriptions: how much text, what size, which colour, how many pictures, for what purpose... They feel some kind of multimedia illiteracy but I am not sure if we can currently speak of "multimedia syntax" as we could speak of visual literacy [Dondis 1973].

Once speaking with Dr. David V. Williams (Ithaca College) we asked him about the best tools for developing multimedia software. He answered "Oh, it is simple, the brain!". It is apparent that there are good and bad answers to this question. The bad answers were "ToolBook, HyperCard,...". His is the good answer. We can also speak about good answers in reference to multimedia production. In this context, the issue is not the specific resources or techniques used, but rather the general role of Evaluation (analogous to "Quality control") as well as the role of End-users in the production process. Starting in 1995, the European Community has introduced these evaluation issues in their funded projects.

This paper is not related to the evaluation of multimedia programmes through the analysis of their direct use, nor through the analysis of feed-back from users, nor through the application of an assessment tool related to the use of pictures and text. Our main aim was to study the continuous quality control process and the end-users participation during different production stages. In the last quarter of 1994 Bartolome and Sandals surveyed and interviewed individuals involved in the Multimedia programme production processes in North America. Questionnaires were sent to more than 100 projects, but only 26 sites returned the answers. The length and, perhaps, the kind of questions on the survey, may have discouraged others from completing the questionnaire. Due to a lack of respondents, some of the initial objectives related to the definition of Multimedia Programmes profiles cannot be discussed. Thus we will only offer conclusions related to the first central theme of this research: "To develop a review of Multimedia projects developing materials for the Educational context, in North-America (US and Canada) by evaluating the end users involvement with the global quality of their products".

2. Theoretical Context
There exists a wide framework within which we can consider the body of research concerning media in education. This framework encompasses such dependent variables as performance outcomes, cognitive processing, efficiency/costs, equity of access to instruction, and such independent variables as media characteristics, student characteristics and instructional method [Clark and Sugrue 1991]. Inside the Production aspects, the research has been specially oriented to design in general, and screen design in particular [Morrison et al. 1991] [Sandals 1987]. Consideration of design has focused on three aspects: (1) screen design, (2) control of the program, and (3) quantity and quality of feedback provided to the learner.

Research in application and design areas has been a key issue during the last couple of years. We feel that new research trends regarding multimedia production will bring about more effective and practical results. An original idea was suggested by Hodges and Sasnett (pg.40) which stated: "Deriving from the philosopher Nelson Goodman’s observations on art, the proper question should not be what is good design, but when is good design. For our purposes we can define good design as effective communication. When a message is communicated effectively, then there is good design... The design of an interface depends entirely on what it will be used for" [Hodges and Sasnett 1993].

That does not seem to say a lot about how to produce multimedia programmes, but this idea includes a key element: the validity of the design is related to its use... and, by implication, to the user. It is from this perspective that we can consider the important role of the user during the design process in order to evaluate the success of the final product.

Given that the end-users do not necessarily have good skills in designing, drafting, painting, and recording video, it is logical to suppose that they will be unfamiliar with the contents of the programme. It is quite clear that its role is situated primarily in the area of the evaluation and quality control. And so we have arrived at the theoretical nucleus of our research.

3. Methodological Considerations

The study is based on answers to an extensive, multi-section questionnaire. The sample includes 26 multimedia projects specifically referred to by their educational and instructional objectives. The data came from different people directly involved with these projects, usually in the role of a coordinator. The data was collect using distance media: mail, fax and e-mail. These 26 programmes represent the work of more than 160 people during an average time of 2 years. These expenses were more than $300,000 in direct costs, an estimated 2 to 3 million dollars in human costs.

These programmes are recent multimedia developments. Nearly everyone started after 1990 and the last versions ended between 1993 and with the data collected by 1995. More than 80% of them were finished in 3 years or less with most in 1 or 2 years. In several cases, work is in progress on new versions.

This sample is not representative of industrial multimedia programmes: most of the programmes are oriented to Academic users, and a few related to Teacher Education. That is a consequence of the objective of this work and of the sample selection process. Some results are coherent with this, such as the average cost (smaller than for industry), the average development time (longer than for Industry), and the programming tools (authoring languages were used more than programming languages). More than half of the programmes were related to Science and Technology [Fig 1].

Figure 1: Distribution by user definition and by programmes content.

Approximately 40% of the developers used tools similar to the "Hypertext" paradigm (HyperCard, ToolBook,
most of them used "HyperCard". One must consider the lower relative cost and the more open distribution licenses of HyperCard vs. Coursebuilder, and of ToolBook vs. IconAuthor or Authorware. In regards to the "classic" programming languages, "C" has the most acceptance. The use of a Macintosh system is also characteristic of the academic environment for programme development (56%).

4. General results

First, we will include some descriptive result.

Graphics, text, or sounds...?

The use of "text" was the winner! In 52% of the programmes, there was TEXT in EVERY SCREEN, while in 44% of the programmes there are no VIDEO SEQUENCES. The use of these elements is conditioned by characteristics and needs, so it is reasonable that animations and video sequences are used only occasionally (in 52% and 40% of the cases, respectively). But, if we look at the proportion of programmes that are not using video, it becomes clear that multimedia programmes depend heavily upon written text. It usually is difficult to design a programme without text -- but does this mean that it is impossible? [Fig 2]. The technical restrictions did not seem to account for these results.

![Figure 2: use of different information channels.](image)

The interface: from person to machine

Despite the number of computers with sound and video boards available and the multimedia character of these programmes, the mouse is the preferred interface with a keyboard being the next most popular choice. Voice and Video Capture (to the computer) have a small role [Fig 3]. At this moment, most of the Macintosh Computers include a microphone and an Operating System which allows the user relatively easy access to the voice medium. It will be interesting to observe the shift to these systems in coming years. Some of the newer developments in the field of AI will encourage the incorporation of these interfaces in the future.

![Figure 3: the main input source.](image)

Money, money, money...

Currently, it is difficult to check the actual cost of production for multimedia programmes in academic environments because personal and overhead costs are not estimated. This contributes to the prevalence of very "cheap" programmes: 25% required less than $1,000 and 30% required more than $20,000 [Fig 4]. How does one recuperate these costs? Nearly half of these programmes are being sold.
The Instructional Design of programmes

Ninety two percent include some type of activity or question, but only 48% include such learning activities as exercises, questions, or problems. So even though most programmes involve some kind of user feedback, many do not involve learning activities perse. Considering that Practice and Tutorial models are mostly based on Behaviorist theories, it makes sense that the Constructivist approach is under-represented in regards to the design of multimedia programmes. Most of the information based programmes are presented as Hypermedia [Fig 5]. The question one must ask is: are they actually hypermedia or are they really Data Bases with sophisticated access systems?. Our own categorization system [Bartolome 1992] is consistent with that of other authors [Schwier and Misanchuk1993] [Gayeski 1995].

Quality Indicators

We have considered some indicators that could reflect the quality of these programmes: (a) a help system, (b) ease of user control over the programme, (c) variety of levels for different users, (d) Assessment (or Evaluation) system, (e) Feedback summary for the user. 12% of the programmes had less than three of these quality indicators. The latter three (c, e) are usually given the least attention [Fig 6].

Production

Is it possible to prepare multimedia in a manner similar to the way a teacher prepares notes for his/her students? A third of the programmes were developed by only 1 or 2 people [Fig 7]. Can we therefore say that most of the multimedia programmes are actually the result of team work? There is a significant relationship between the number of people and the cost of the programme: 100% of the projects with $1,000 or less in costs were produced by one or two people. We have also considered the number of people involved in the script as a quality indicator. The quality of programmes surveyed is high because 80% of the scripts are the work of more than one person [Fig 7]; the result is even more significant if you consider that 30% of the programmes have been produced with only 1 or 2 people.
5. Results related with quality control and end-user participation

Programmes were evaluated frequently during the production process (65%) and at the end of the production process (68%). This result is not related to the number of people involved in the project (p>0.05). Programmes that evaluate “during” appear to be the same that evaluate “at the end of” (p<0.001). This evaluation is not limited to once during but occurs several times. Although there is no clear taxonomy, we have found the following possible profiles regarding the projects:

a) Those who never assess the programme. (25%).
b) Those who assess the programme one time, either during or at the end of the process (15%).
c) Those who assess both the computer software and, later, the final product (15%).
d) Those who assess the results in several different stages of the production (45%).

The participation of end-users approaches two-thirds. However, less than 50% participated in evaluation tasks "during" the production. It is necessary to consider the participation in the evaluation tasks at the end of process.

The self-evaluation of the product is very positive: 100% consider their products good or very good, and more than 95% believe that their programmes achieve their educational objectives. This maybe related to the restriction of the sample: it is more probable that people satisfied with the results of their work would answer the questionnaire than would dissatisfied people. It is also relevant that these results include programmes lacking any kind of evaluation either during or at the end of the development process.

The number of copies distributed is related (near p=0.01) to the overall results of the self-evaluation, or to the achievement of educational objectives. The opinion of actual users has also been collected but no relation has been found between user participation and the self-evaluation results.

6. Conclusions

It is not appropriate to offer conclusions from a such a small sample. Some conclusions about other aspects of the survey have been offered elsewhere. 2 key aspects related to evaluation and end-user participation appear to be:

(1) Most of the projects used continuous evaluation during the production of the programme. Participation of end users was taken into account, though this was not the case for all projects.

(2) There appeared to be an objective mechanism used to control for the quality of some programmes but it was not applied systematically across all projects.

We must comment on the fact that the participation of end-users was higher than we expected and this is a very positive result of our work.

Literature references


MURIEL: a European Multimedia Interactive Training System for Librarians

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Abstract: MURIEL is a European project in the telematics field, which is developing a multimedia interactive training system suitable both for librarianship students and for those already working in libraries. The courseware is accessed over ISDN and the software includes a tool for the remote joint processing of material. The aims and the achievements of the project are described as is the way in which multimedia content is put onto the system. Copyright problems and solutions are discussed. Work to be carried out during the remainder of the project is outlined.

1. Introduction

Firstly, I should like to explain my involvement in the MURIEL project and then I shall describe the project itself. I work at the British Library in Boston Spa in what is called the IFLA/Copyright office. This small office comprising only six people, three of whom are part time, carries out work for the International Federation of Library Associations (mainly concerning international interlending and the Universal Availability of Publications) and also for the British Library concerning copyright. It is primarily through being a recognised centre of expertise on copyright that the Office has been invited to be involved in various European Commission projects over the last 3 or 4 years. MURIEL is one of these projects.

2. Overview of the MURIEL Project

MURIEL stands for Multimedia Education System for Librarians Introducing Remote Interactive Processing of Electronic Documents. The two year project began in January 1995 with a budget of 483,740 ECUs (roughly $604,000) with just over half of this money coming from the LIBRARIES Programme of the European Commission. Partners in the project from its inception are the British Library in Boston Spa; ELEMEDIA SpA: Training Procedures and Technologies, which is in Rome; the Institute for Library Science, Humboldt University in Berlin; the National Research Council of Italy (CNR), which is also in Rome; the School for Library and Information Studies in Maastricht and TELES GmbH in Berlin. TELES GmbH is the prime contractor and project leader.

2.2. Objectives of the Project

MURIEL is a Research and Development project on new, innovative telematic systems, services and applications in libraries, its main aim being to see how these can be applied to libraries and library schools. Its objectives are:

- to create a multimedia interactive training and education system for librarians
- to integrate a tool for the interactive remote joint processing of electronic documents for resource sharing
- to interface libraries throughout Europe via international ISDN (Integrated Services Digital Network) communication links
- to demonstrate and evaluate innovative telematics services and online educational and cooperative working systems

These objectives were to be achieved during three phases by means of Workpackages. Phase 1 would produce a theoretical model for the electronic courseware and the content of the electronic documents. In Phase 2 the electronic documents would be developed, the courseware implemented, the remote joint-processing tool refined, local field trials held, and the ISDN infrastructure set in place. In Phase 3 international field trials would be held and the results of the project disseminated.

2.3. Progress of the Project

In January 1996 the project reported back to the Commission on its progress. At this point a working prototype had been produced and tested in local field trials in real education and library environments. The ISDN network had been set up between the partners and was being used for communication between the partners using ‘phone, fax and file transfer. Various reports (Deliverables) had been presented to the Commission. These included one on the theoretical model, specifications for the prototype, evaluation of the local field trials, and a study on copyright issues. A logo had been designed and a publicity leaflet had also produced.

2.4. Problem Areas

The main problem which arose during the first year was the lack of content. Most of the effort had been spent on getting a system up and running and in continually modifying and improving it. This meant that the local field trials could really only evaluate the software and not the content because there was very little information on the system at that time. The results were therefore of limited value. Also the concentration on designing and implementing courseware and content meant that copyright issues were only very briefly discussed.

Other problem areas were that it became obvious that there was a need for training partners both in the use of ISDN and also in the production of multimedia.

3. The MURIEL Prototype

There are three constituent parts in MURIEL - the courseware, the administrator and the template constructor. The MURIEL courseware is built up of different Information Units, which are parts of chapters in courses. The course material is provided by Information Providers, who can also input additional information, links, keywords, glossary terms and provide help.

The editor or administrator (which in the long term could be a commercial company, a university, a library or an association) can insert and delete Information Units. It manages courses, chapters, users and roles.

The user who consults a course, is navigated round the system, can consult the glossary, completes exercises, search by keyword or full text, find out where he is at any time, and obtain help if necessary.

Functionalities of the system include key word searching, full text searching, “I am here”, previous and next page movements, backtracking, movement to different levels, text modification, keyword management, adding links to
another Information Unit and deleting such links. Messages can be sent to the editorial board by e-mail, sound tracks can be listened to, there is access to a glossary of terms, to exercises, and to further information.

For each Information Unit a template constructor has to be completed. This contains details on the title, author, course, chapter, language, format, holder of any copyright, and keywords. Once the template file has been constructed, the multimedia information can be automatically inserted (providing it is in the correct format e.g. images must be in bmp format), exercises may be added, links may be made to existing Information Units and definitions may be added to the glossary. The template and content files are then sent to the editorial board, which can preview the item and insert the Information Unit if it meets the required quality.

By the end of the project’s first year MURIEL had worked towards meeting the necessary requirements by incorporating the following features:

- A large amount of multimedia electronic documents in the form of text, image, sound and video

  MURIEL can support text, image, sound and video and allows multimedia document consultation and modification. However, there was a lack of content on the system.

- One course to be elaborated by different teachers simultaneously for a standardised European Libraries’ Curriculum. [At present there is no common European curriculum for librarians and no comparable certificates within the European library community. This prevents librarians being employed easily in other European countries, let alone elsewhere. It was hoped that a centralised European multimedia training server, which can be accessed throughout Europe by students using multimedia workstations, would help to harmonise European curricula in the field of library and information science].

  Several teachers throughout Europe can access the multimedia courses to search for information or to modify or add to it. There is a common layout.

- Courses accessible over high speed networks for distance learning

  There is a client/server architecture over high speed networks, hyperlinks for flow control, powerful functionalities such as navigation, and exercises for assessing knowledge. At present local versions of the prototype are being used but eventually data will be transmitted over international ISDN links from a server and different Local Area Networks will be connected via ISDN in order to provide fast, secure and economical information exchange between teachers and students.

- Guaranteed content quality

  Information providers are experts in their fields, there is an editorial board, access to the system is protected, and there are different functionalities for teachers, students and the editorial board

- Integration of multimedia material in an automatic manner

  Automatic insertion tools

- Ease of use

  Graphic user interface, online help, instinctive user interface, layout uniformity, structured course, user manuals, learning by doing facilities

- Easy facility to modify course material

  Course, link and content management

- High interactivity between teachers and students
4. Copyright Problems in MURIEL

There are various copyright issues in MURIEL and at the time of writing some have not been resolved or even fully discussed amongst all the partners. Firstly, the software itself must be protected. It is envisaged that this will be covered by licensing purchasers on a sliding scale of costs depending on the number of proposed users. Secondly, Information Units put onto the system must be protected. If materials are produced specially for the project a contract will list the conditions under which material can be used. However, as part of the aim is to constantly improve the quality of information on MURIEL and to be continually improving courseware, this means that information providers will have to sign an agreement allowing this. It is envisaged that minor changes could be made without going back to the original author but in cases of proposed major changes the first author would be advised. He could agree to the changes in which case there is no problem. However, if he disagrees, the editorial board will decide which version to keep on the system or may even decide in extreme cases to keep both versions on. It remains to be seen how many information providers will agree to such a contract. It could be that MURIEL could end up with two kinds of Information Units, those which can be amended and those which cannot because of copyright restrictions. Further problems arise when the project wishes to exploit material which already exists, whether in electronic or other form. For electronic material there will have to be negotiations with the producers to allow them to be networked. For non-electronic material there is the additional need to negotiate rights to convert material into electronic form in the first place. Producers will need assurances that their work will not be unfairly exploited and are unlikely to allow any manipulation. They will probably require some concrete form of protection not just verbal assurances. For some time it has been said that the way to protect the copyright of electronic items lies in the technology itself; it is not sufficient to rely on the law or on contracts. For electronic material there will have to be negotiations with the producers to allow them to be networked. For non-electronic material there is the additional need to negotiate rights to convert material into electronic form in the first place. Producers will need assurances that their work will not be unfairly exploited and are unlikely to allow any manipulation. They will probably require some concrete form of protection not just verbal assurances. For some time it has been said that the way to protect the copyright of electronic items lies in the technology itself; it is not sufficient to rely on the law or on contracts. However, a combination of contracts and technology can give the necessary assurances to rights owners that their work will be protected and that they will receive adequate payment. Training material often requires the use of small elements of material from various sources. MURIEL will be a chance to test different methods of acquiring permissions from owners to include their material, especially when such small amounts are required. Other projects have shown that it is both time-consuming and costly to obtain permissions. In MURIEL, as yet, however, this work has not begun.

Most countries have their own copyright laws and those which are signatories to the Berne Convention offer some mutual protection to other members. Supplementary licences may enable those involved in education to copy more than national legislation otherwise specifies. Such licences, however, probably apply to paper copies only. Although it is hoped that there will, in the not too distant future, be some harmonisation on electronic material within European Union legislation, at present in Europe, digital material cannot be stored without the permission of the owner of the copyright in that material, whatever its format. Permission for storage has to be sought for any material which is more than “insubstantial”. Although on the face of it, it seems simple to request permission to use an item (and pay a fee, if necessary), in practice it can be a time-consuming and expensive business. Often it is very hard to track down the rights owner and publishers may have gone out of business. What is therefore necessary is a system in which the copyright implications of using copyright material are automatically taken care of without the need to seek individual permissions and which also keeps track of digital material once it has been released over networks and is available for use by students at remote sites.

To avoid reinventing the wheel MURIEL will be using the findings of other European projects and techniques developed by them, in particular, CITED (Copyright in Transmitted Electronic Documents), which developed a generic model for monitoring use and collecting royalties, and COPICAT (Copyright Ownership Protection in Computer Assisted Training), which has devised a system for tracking digital material to enable the payment of appropriate royalties combined with a high degree of security against unlawful access. There are now various
other European projects looking at Electronic Copyright Management Systems and work here is being closely monitored by MURIEL.

5. Future Work in the Project

If we look again at the project’s original objectives, we can measure its progress and see where effort must be concentrated in the project’s second year.

- Create a multimedia interactive training and education system for librarians

  The courseware needs improving, subject areas must be well defined, much more content needs to be added and exercises must become more sophisticated. Obviously in the time available a full electronic textbook on librarianship cannot be provided but in the long term, however, MURIEL could host a whole collection of courseware relevant to the initial and ongoing training needs of librarians and information specialists.

- Integrate a tool for interactive remote joint processing of electronic documents for resource sharing

  Although WYSIWIS (What You See is What I See) has been achieved over ISDN, training and much more practice are essential.

- Interface libraries throughout Europe via international ISDN communication links

  ISDN tools such as ISDN for Windows for Workgroups, WYSIWIS, file transfer etc. have been set up but more training and practice are needed. There also need to be connections to existing library Local Area Networks and the Internet to interface existing library resources and services to the project application.

- Demonstrate and evaluate innovative telematics services and online educational and cooperative working systems

  Local field trials were held and the system evaluated on a basic level. International field trials are still envisaged. Future trials need to really evaluate the quality of the learning. To do this two groups are envisaged; one group using MURIEL and the control group not using it.

  In addition, the MURIEL consortium will take a closer look at the inclusion of third party material and try to prove that this can really work. It will also look at emerging standards such as HTML so that it does not become just a proprietary system out on a limb. A full dissemination strategy will also be agreed and acted upon.

6. Conclusion

By the end of the project MURIEL will have demonstrated and evaluated the practical applications of innovative telematics systems and services in online education, training and resource-sharing for librarians. As well as producing courseware dedicated to librarianship the project will have brought new systems, services and applications to the library community. At a time of great demand for online training, distance learning and teleworking MURIEL will have produced a multimedia interactive training system dedicated to the needs of librarians. Librarians will then have a state-of-the-art windows-based education system plus a sophisticated tool allowing them, despite being geographically dispersed, to work cooperatively on electronic documents in remote joint editing sessions without leaving their workplaces.

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Learning as Action: A Social Science Approach to the Evaluation of Interactive Media

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Abstract: Some problems of evaluation methods that are commonly used in the attempt to assure the quality of interactive educational media are outlined. The authors present their heuristic model of the learning process as the basis for an alternative approach. It has the advantage of bringing the social aim and situation of the learning process into focus. This model leads to a qualitative approach to software evaluation which also helps to define appropriate and creative settings for the use of the software.

Problems of Educational Software Evaluation

The problem of quality in interactive educational media has accompanied the field since its beginnings. Numerous researchers tried to define criteria of software quality and to compile catalogues from them (see [Doll 1987], [Thomé 1989], among others). The idea was to translate these catalogues into checklists that could be of practical use for teachers and trainers in judging educational media.

Checklists have the advantage of being cheap and simple to use: no software users (= learners) are needed. But this is also their disadvantage: they cannot make predictions on the context, that is, the specific target group, learning goals, situations etc., in which the software can be more or less usable. What they are left to check are those aspects that can be tested and judged without context. These are, however, mostly those questions that can be applied to any kind of software, i.e. whether it is robust, error-free, well-designed, well documented, easy to learn and user-friendly. The specific character of educational media has to remain outside this method.

Empirical methods of evaluation, on the other hand, are costly and time-consuming. They are applied to only a few selected cases of software (often those programs developed by the researchers themselves). One well-known method is based on the comparison of groups of learners. One group works with media support, while the reference group - which has to be comparable in age and gender distribution, prior knowledge etc. - works without software support - with books, classroom teaching etc.). The comparison (most of the time by standard tests) of both groups is supposed to reveal the difference that results from the use of interactive media - be it positive or negative.

For all its complexity, this method has its pitfalls, too. What can be tested objectively is the memory of the contents learned. However, this amounts to an implicit reduction of learning to the mere reproduction of facts. Furthermore, test groups would be, strictly speaking, only really comparable if both traditional and technology supported teaching were completely identical in contents, goals and methods. But if new media are used in this way, they rightly provoke the question what, in these circumstances, is "new" in them.

The problem with both methods is that they reduce the learning process to a number of individual factors: lists of criteria consider the software without the learners, and comparative studies, while considering the learners, treat them as isolated receptacles of knowledge. Learning with software is, however, a social process in at least two
ways: first, it takes place in a certain social situation (in the classroom, at work, at home) and is motivated by it. Secondly, any relevant learning process has as its goal the ability to cope with the social situation (professional or everyday tasks, etc.). The evaluation of interactive media then has to satisfy three conditions:

1. It has to take into account the social situation in which the media are used, and must not be limited to the media themselves
2. It has to take into account the goal of dealing with complex social situations and must not limit itself to the isolated individual learner.
3. It must take into account the specific forms of interaction between the learner and society. These interactions range from the passive reception of static knowledge to the active design of complex, dynamic situations that characterizes the "expert".

These requirements eliminate evaluation methods that can only pick out single factors. At the same time, they make an "objective" discussion of media quality difficult. In what follows, we will first outline a heuristic learning model that can be used to define and to design learning situations on the basis of these three conditions. We will then try to propose an evaluation procedure where the concept of absolute quality is replaced by relative values. These values are defined and determined in discourse - with the software, with the situation, and with the scientific community.

A Model of the Learning Process

The model that we propose is inspired by the work of Dreyfus and Dreyfus [Dreyfus and Dreyfus 1987] who studied the learning process from novice to expert:

1. A novice who does not know anything of the subject he/she is approaching has to start with taking in the facts and rules of it. The application of them to the novice's practice or exercise of the field has to be automatic: the novice cannot decide on which rules to apply and learns them as context-free. Practice is thus limited to imitation, to exercise.

2. The beginner can start to learn the context of the rules, i.e. that there are different rules to apply in different cases. The practice becomes more varied and more adapted to individual cases, but it is still impossible to act autonomously in the field.

3. At the third stage, the competent person grasps all the relevant rules and facts of the field and is, for the first time, able to bring his/her own judgment to each case. This is the stage of learning that is often characterized by the term "problem solving": the conscious and often laborious decision-making process based on the vast repertoire of facts and rules available to the learner.

4. Contrary to most learning theories, this approach, however, does not stop here and does not consider competence to be the final goal of learning. The fourth stage is called fluency and is characterized by the progress of the learner from the step-by-step analysis and solving of the situation to the holistic perception of the gestalt of the situation. Just like the situation, its solution also starts to present itself as a holistic pattern or gestalt together with the problem.

5. This ability of gestalt perception is brought to perfection by the expert, the final stage in the learning process. An expert identifies him/herself with the complex real-life situation in which he/she is bound to act. The "art" of the expert consists not in solving problems, but in constructing them out of the amorphous complexity of life. This act of creating the problem already contains its solution.

Most theories of learning stop - as we mentioned above - at the level of competence. Traditional Artificial Intelligence research with its focus on the representation of facts and rules and on problem solving [Baumgartner and Payr 1995a] has no small part in this narrowing of our perspective on learning. Practitioners and those who are concerned with their education, like Donald Schoen ([Schoen 1983], [Schoen 1987]) have never been satisfied with this view. Schoen's concept of the "practitioner", for example, shows close similarity to the "expert" characterized above, and his writings about the education of practitioners that have inspired so many educationalists offer an account not only of what it means to be a practitioner, but also of what it could mean to "teach" them.
The problem that we saw was the gap between the view of beginners through to competent learners and the view of experts-to-be: There did not seem to be a hint of how learners pass from one level to the other, nor a unified picture of the strategies required for educating experts or practitioners. Out of this need, we developed the heuristic cube model [Fig. 1] that combines the (meta)contents of learning with the goals of the learner and the learning strategies (see [Baumgartner 1991], [Baumgartner 1992], [Baumgartner 1993], [Baumgartner 1995], [Baumgartner and Payr 1994], [Baumgartner and Payr 1995b]).

![Figure 1: The cube model – a heuristics for defining educational (software) situations.](image)

Learning Contents

From left to right, the cube diagram shows learning contents on the meta-level, i.e., not the "subject", but the task of the learner in a certain stage and situation. This dimension offers a fine-grained differentiation of the coarse subject description (e.g. "equations with two variables"). For example: Should the learners be able to solve the equations given a certain method, should they also be able to choose the adequate method, or should they even be able to extract the equations from an observation or a verbal description? In the first case, the contents of the learning process are context-free rules (like rules for transformation of equations). In the second case, they learn context-sensitive rules, i.e., they have to decide which rules are to be applied in what case. The third level (problem solving) deals with solving given systems of equations. On the more advanced levels, the learners first will have to construct the problem themselves out of a complex, real-life situation, before solving it.

Goals of Learning

From bottom to top, the cube represents goals of learning in their order of complexity. This dimension characterizes the types and possibilities of interaction between the learners and the "world" (society, nature). It is based on the experience that novices cannot successfully deduce a solvable problem from a complex real-life situation.

This approach to goals of learning can easily be misunderstood as the reincarnation of traditional, hierarchic notions of learning, where novices had to progress slowly and painfully from rote learning of facts to mindless drill in order to finally be found "worthy" of more complex tasks. This is certainly not what we mean here: rather, this dimension reflects the common experience of learners in which they spontaneously choose those
strategies of interaction with the subject that protect them from an overload of complexity. A novice of the language in a foreign country (= complex real-life situation) limits herself, in a first step, to grasping isolated words or idioms in the flow of speech of the natives. Only later will she be able to perceive and analyse longer parts of speech.

Teaching Strategies

From the front to the rear, the cube model shows three different teaching strategies. This dimension attempts to outline the role of the teacher, but also that of the educational media: Are they "teachers" (= explaining, demonstratating), "tutors" (= observing, correcting) or "coaches" (= accompanying, participating)?

Learning Goals and Educational Media

Beside the goals of learning (y-axis in the diagram), we put a certain type of educational software. This typology is quite traditional in itself, but, integrated into the general model of learning, it is a starting point for classifying software according to the types of educational interaction it allows, and not only according to design criteria, as is often done. This typology of educational media is done here for only one dimension of the "cube", but could be done equally well for the others. Doubtlessly, there is an affinity between a certain goal, certain contents and a certain educational strategy. For example, we cannot easily imagine how a learner can master complex situations (contents) without acting him/herself (goal) in a situation where the role of the teacher is that of a participating coach (strategy). But what we want to underline by listing all the possible varieties that can lead the learner from novice to expert is that each sensible combination can be justified in a certain learning situation. Contrary to researchers and developers who are mainly concerned with "interesting" cases of educational media and therefore prefer complex media (simulation, games, microworlds) to seemingly "old" and primitive media (tutorials, practice, presentation), we try to express, in this model, that each type and use of media can be justified and adequate, provided that their use is adapted to the situation - the current goals and contents and the appropriate teaching strategy.

It is therefore also important not to lose sight of the "final" goal of the learner, that is, to become an expert or at least a fluent practitioner in the field. This holistic view of the learning process helps to avoid the risk of a narrow and biased view of learning that is often to be seen, especially in the field of educational technology where the (restricted) potential of media often prompts an equally restricted view of learning.

Evaluating by Generating Questions

The relevance of this model for the evaluation of educational media lies in the support it gives to the teacher or evaluator in defining the learning situation from the viewpoint of the level that the learners have already reached. By applying it to classes of educational software, it also provides a first orientation not only on the type of media to use, but also on the type of use that could or should be made of this software: most modern educational software packages are complex enough to allow different types of use, e.g. as a pre-defined problem to solve or as an open scenario more or less restricted by pre-set parameters.

To pass from this static analysis of given situations and software functionalities toward a more dynamic approach to evaluation and didactic integration, we suggest a procedure in the form of so-called "generative" questions, as they are used in qualitative social research methods like "grounded theory" ([Glaser and Strauss 1967], [Strauss 1987]) These are questions that open up the problem space, draw attention to the problematic points and make solutions comparable. The "generated" concepts can be compared to the criteria that are used in check-lists. But, instead of being pre-defined, these criteria are developed in the context of the given means (media) and ends of the learning situation.

As generative questions address the specific situation, they are not fully predictable. We will try here to define five families of such potential questions. This presentation can neither be complete nor equally relevant for each case:
1. Questions on the relation between different levels of complexity, e.g.: How does the way in which rules are learned prepare the learner for the task of problem solving?

2. Questions concerning one level of complexity: How is complexity increased inside one level? How can complexity be reduced?

3. Questions on (implicit) meta-strategies: How does the software support the acquisition of strategies to control the situation? How does the software help the learner to develop learning strategies (like diagnosis, planning, observation etc.)?

4. Questions concerning teaching strategies: Which methods are used to support the construction of mental models, the learner's own activities, or her growing involvement and responsibility?

5. Questions on the social situation: How is the social context integrated? How does the software prepare the step from virtual to real world? Are there slots for social activities, teacher intervention, and integration of other media?

The aim of the generative questions is to uncover the didactic strategies that underlie the educational medium. In this sense, they are instruments of evaluation or of comparison of different media. At the same time, however, these questions reveal what the medium cannot bring to the learning situation and what must be looked for elsewhere. Educational media, however sophisticated, play only a small part in the complex learning process. The main part - be it the transition to real-life complexity, be it the background of facts and rules - is left to either to the learner or to the designer of the learning process to provide. In this sense, these questions can help them both to put educational media into perspective and to find in them the clues to create a learning situation that is oriented toward the overall goal of educating experts.

References


User Navigation Strategies for Multimedia Tutorials

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Abstract: Multimedia has gained widespread popularity as a technology that is useful in many areas. This paper addresses the use of multimedia in an educational environment for the creation of instructional materials. The authors have observed what seems to be a pattern or relationship between the instructional objectives and the navigation strategies used in developing in-house multimedia based tutorials. Three examples of these tutorials were selected to depict different navigation patterns that were developed through user testing to satisfy different instructional requirements.

Introduction

Multimedia and Information Superhighway are two computer related buzzwords of the decade. Questions regarding the use of and the place of both in society abound. Both have captured the imagination of the media and are enjoying unprecedented coverage in the media and commercially. One popular use of multimedia is for education and training. Within the area of education and training, one way multimedia is being used is for the creation of tutorials. The creation of multimedia tutorials is a multidisciplinary endeavor. The successful multimedia tutorial must integrate many components including multimedia technology, tutorial content, instructional strategy and user interface design and navigation.

The proliferation of multimedia applications that are available over the counter and in the business environment is occurring faster than the acquisition of knowledge and understanding of the relationship between the user and the technology. A better understanding of the relationships among the various components of multimedia applications is needed in order to speed the process of developing quality applications. Guidelines, tools and techniques from some of the disciplines involved are being adapted and used to aid in the development of multimedia applications. Research is still needed to provide answers to questions about how to develop applications that meet user needs. In this paper, the question that is being posed through the analysis of selected tutorials is, are there user navigational strategies that can be identified and that facilitate certain types of learning?

Navigation

During the development of a multimedia application, storyboards and navigation maps are useful tools for planning the application's content and navigational structure. During the design process the two development aids are integrated. A navigation map simply outlines the connections or links among the various areas or parts of the content. It shows the logical flow of the content that will be supported via the user interactive interface. Basically the designer works with four basic organizing structures, linear, hierarchical, nonlinear, or composite. Even though, users like to have control and to have a sense of freedom, it is important to provide landmarks and roadmaps or guides that enable users to be successful in navigating through the system.

Navigation within systems has been and continues to be an area of interest and investigation. There is ongoing research into the problem of navigating through hyperspace [Rivlin, Botafogo, and Shneiderman 1994]. Whether or not the system or application is one which uses a hypertext database, researchers, designers, and users recognize the
Teaching Strategies

The need to incorporate instructional strategy in the multimedia tutorial adds another dimension to the application development process. The developer must utilize knowledge and information from yet another discipline. Each tutorial has its own learning goals or purposes. The education strategy of the tutorial will differ depending on the goal or skill level desired. Henderson [Henderson 1992] discusses the following three teaching strategies in the context of developing a multimedia tutorial: didactic learning, experiential learning and reflective learning.

In the didactic learning mode facts are presented in a manner that is similar to that used in a well-illustrated text; even though in the case of the multimedia tutorial, the text is electronic. The tutorial incorporates additional detail which might be similar to footnotes or appendices. It also includes visuals such as graphics, still and/or full motion video and may include sound.

The experiential learning mode is characterized by presenting the content in such a manner as to foster decision-making. The learner is expected to be able to apply the knowledge gained to scenarios or case studies and make appropriate decisions. The third type of teaching strategy, reflective learning, takes the student to a higher level of application of knowledge than does experiential learning. In this mode the learner is presented with extended cases to help him gain knowledge through insights and actively applying concepts and information to the situation under consideration.

Just as the material presented differs in form and organization for each of these teaching strategies, the way in which the learner needs to manipulate his path through the content differs. The tutorial designer needs to recognize these different needs and plan navigation patterns to support the teaching strategies being used in the tutorial. In developing several tutorials, as part of a faculty mentorship program, this need for supporting or designing different navigational approaches became apparent during usability testing. In this paper, the navigational strategies utilized in three of those tutorials will be discussed and an attempt will be made to categorize the strategies and link them to the learning goals.

Description of Tutorials

Seams & Stitches (S&S)
The purpose of this tutorial is for students to recognize and categorize seams and stitches. S&S allows the retrieval of detailed information about seams and stitches based on Federal Standard 751a, which specifies six stitch classes. The user can retrieve and set a unique state in each of the classes. This feature permits instructors and students to engage in tasks or activities involving the comparison, selection and appreciation of the different types of seams and stitches. S&S includes linear navigation among classes and non-linear navigation within a class. Figures 1 shows a sample state of stitch class 500.
Multimedia Plastic Tutorial (MPT)

MPT is an application aimed to help students understand the most important phases involved in the manufacturing process of plastics. MPT, using a book metaphor, presents a comprehensive view into three main areas of plastics: a) Quality, b) Categories, and c) Processing. The pages in this electronic book make substantial use of multimedia technology. MPT includes a navigation controller that enables linear (depth-first) and non-linear navigation (see Figure 2). Non-linear navigation is achieved by retrieving the initial page of each of the chapters (by selecting chapter name in the navigation controller) or by selecting any page of the book depicted in a hierarchical map (which can also be reached by the map button in the navigator controller).

The user location (where am I?) within the book is always explicitly posted through page headings and highlighted indicator buttons at the left of chapter name in the navigator controller. Within the map, the highlighted block shows the last page visited by the user (See Figure 3). These intuitive cues keep the user oriented throughout the tutorial.
Body Composition

This multimedia application was designed to aid faculty in the effective delivery of instructional material in a classroom setting. The student goal was to be able to select appropriate means to measure body composition in specific circumstances. Body Composition is comprised of three modules which are briefly described below.

1) Under Water Weighing (UWW)

Body density is the ratio of body weight to body volume. This may be determined by underwater weighing. The difference between body weight measured in air and submerged in water is body volume. Since fat has lower specific gravity than water, fat floats on the surface of water. Once body density is calculated, then body fat can be determined.

2) Bioelectrical Impedance Analysis (BIA)

BIA is based on the principle that impedance to an electrical flow of an applied current is related to the volume of the conductor (human body) and the square of the conductor's length (height).

3) Skinfolds

Approximately one-half of the body's storage fat is subcutaneous. The measurement of skinfolds at various appropriate body sites should reflect the amount of this storage fat.

All of these multimedia instructional modules share the following structure:

I. Principle
II. Advantages & Disadvantages
III. Method
   A. Equipment
   B. Process

The information space can be navigated using a hierarchical strip of buttons that portray the aforementioned structure. The Figure 4 depicts body composition's main screen.
The user can easily compare principles, advantages, disadvantages, and methods among the different techniques by selecting the appropriate buttons. The size and position of the buttons depict a flattened or single branch of the hierarchy used. This hierarchical color coded representation of the information space minimizes the number of selections a user needs to make when engaged in comparing the different body composition measure techniques.

The objective of the lines connecting the hierarchical strip of buttons is twofold. One objective is to enable the user to navigate to any level within the hierarchy. The second objective is to depict the user’s current position, thus helping him/her maintain his/her orientation throughout the tutorial. The strip of icons emulating a film strip at the bottom of the screen provides the user with visual cues indicating the progress within a lesson unit by highlighting the icons from left to right. In addition, these icons permit non-linear navigation within a lesson.

Conclusion

Rapid prototyping methodology was used in the development of these tutorials. The first stage was a series of brainstorming sessions where content experts and production team members were involved in determining content, navigation, and presentation strategies. Developers then built a prototype and had content experts use and react to it. The cycle of conducting review sessions followed by refining the prototype was repeated. This process continued until the tutorial seemed to be constructed appropriately for the intended audience and to meet instructional objectives.

There seems to be a pattern or relationship between the instructional objectives and the navigation strategies used in these tutorials. Even though this paper has only presented three tutorial examples, the production team has observed this pattern during the development of several multimedia-based tutorials. The three presented examples were selected to depict different navigation patterns that were developed through user testing to satisfy different instructional requirements. Future research will attempt to formalize this apparent relationship by the development of a task taxonomy and navigation strategies for multimedia-based tutorials.

Bibliography


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Abstract: This paper develops a creative model for the use of multi-media technology in teaching an introductory course in Humanities. It proposes the idea of "classroom culture" as a way of exploring the complexities of teaching and suggests that the concepts of myth and mythmaking as they are used in literature or religious studies can be useful analogies for understanding and creating more productive classroom dynamics. Finally, it demonstrates how multi-media presentations can facilitate the involvement of students in the classroom ritual thereby characterizing them as story tellers and mythmakers in their own right. Demonstrations include a "Puzzle" module that engages students in the exploration of their own thinking process, and a series of contradictory exercises that challenges the "conventional wisdom" of students.

The Thesis

The general hypothesis of this paper is that students are more enthusiastic participants in a class in which they have a strong sense of "ownership." This sense of "ownership" is engendered mostly by their expectations regarding the class. These expectations are part of the cultural foundation inherent in our society and they are "passed on" in a kind of oral tradition that would best be described using the terms "myth" and "culture." If it would be possible to manipulate these "classroom myths" by, for example, using multimedia "classware" to change classroom dynamics by changing student expectations, we most surely would succeed in changing student performance and raise the quality of their learning.

There are several narrower themes that depend on this central hypothesis. First, that learning takes place best in a conversational environment; that learning is facilitated by multi-modal teaching; and that media can be used to change the culture-based perception of learning environments forced on students by conventional classroom circumstances. It is my contention that carefully crafted computer-based "classware" can be used to develop a pedagogical strategy to facilitate multi-modal teaching; to challenge students and stimulate conversation in and out of the classroom; and to create an environment for learning that "interrupts" the culture-based expectations of college students and gives them a greater sense of "ownership" and responsibility for their own education.

Myth and Culture

By using the word "myth" in this context, I do not mean to indicate a fairy tale or some sort of fabricated story that is so farfetched as to be clearly untrue. I do not mean, for example, the belief that all students have the ability to pass every course, nor that graduating from college will get you the high-paying job of your dreams. What I mean by the term "myth" is the "lived-through assumptions and expectations that create the present-day educational culture (see above). These assumptions are ritualized by such things as desks in a row or even desks in a circle -- or for that matter, no desks at all but only tables and chairs. This is part of the ritual of orderliness that is essential to the educational enterprise and against which you find in some inner city schools the confrontation with "gang" culture or teen myths which thrive on disruption of orderliness.

"Myths are stories which are taken to manifest some aspect of the cosmic order. They provide a community with ways of structuring experience in the present. They inform man about his self-identity and the framework of significance in which he participates" [Barbour, 1974]. For college students, I would point out that the classroom most certainly represents an important aspect of their "community." For serious students, it is clear that going to class is like going to work. To continue the analogy, for less-serious students, the classroom
is like a mini-cosmos where they are sometimes confronted with what seems to them like real life-and-death situations!

A Myth is a story designed to involve those who use it in a common shared experience of what the story is about. A myth is like a "con" in this respect -- it intends to be seductive in the same way that a good stage production pulls its audience into the plot. It must involve the audience or it is a failure. Myths entice us to assume that certain things are true and they promote the consequences of this assumption. In the classroom, the teacher is a "scholar" who knows the truth and can pass on wisdom. The story is something like "go to class where you will learn -- the expectation of some students seems to be of a magical moment where knowledge is infused -- and become an educated person deserving of a good grade. You only have to put in the time."

It is clearly true that "...societies depend upon stories to communicate shared meanings and to set limits as to what is socially acceptable. As Homeric myths identified common loyalties and set boundaries for the Hellenes, so popular art forms today witness to collective world-views and portray current heroes and antiheroes" [Olson, Parr, and Parr, eds., 1991]. These mythological classroom heroes are the students who answer questions (so I won't have to), those who cause no disruption, and those who on occasion provide us with comic relief to name but a few. But how does this concept play itself out?

Finally, our "public stories" or "myths" are clearly influenced by public media, most notably broadcast/cable TV (although the Internet and World Wide Web almost certainly will continue the pattern). The obvious example here was the O.J Simpson trial last year with the hundreds of viewers divided into three distinct subcultures of those who believed him innocent, those who believed him guilty, and those who did not watch. Each group has developed a set of stories/myths to support the central unifying vision of each and to justify their expectations.

If it would be possible to use media to shift the paradigms or expectations of college students in the classroom, it would be possible to shift the outcomes of teaching.

"Classroom Culture"

According to Terrance Deal and Allan Kennedy every organization has its own culture; and their studies show that sometimes this culture is fragmented and weak and sometimes it is strong and assertive. They define this culture as "...a cohesion of values, myths, heroes, and symbols that has come to mean a great deal to the people who work [within the organization]. . . ." Whatever its structure, "culture"...has a powerful influence throughout an organization; it affects everything -- from who gets promoted and what decisions are made, to how [members] dress and what sports they play." Moreover, strong culture organizations most often achieve their goals [Deal and Kennedy, 1982]. Simply put, culture is "the way we do things around here."

Using the model of Deal and Kennedy, I want to suggest that there is also such a thing as a "Classroom Culture" which is ingrained in our students from the moment of their first "schooling." This culture is also dependent upon the myths, heroes, symbols and values that students have found relevant to their lives. In this case, most good students realize at an early age what most teachers expect -- be prompt, sit in a row, don't talk out, answer the questions correctly and get a good grade! They are also told in high school what to do to score high SAT's and what to write on their application so they will be accepted by a "good" college. Many students come to college with expectations regarding a career: "I want to be a doctor -- a lawyer -- a business executive, etc." Often these "hero images" are based on parental suggestion or observations of family friends. In other words these student expectations are founded upon a family oral tradition or myth that justifies these same expectations and makes them "real."

Emphasis seems to be on "form", and if we analyze their heroes and myths, we find "form" to be the highest value. Once they have "mastered" the "form" of the classroom it is subsumed into the stronger culture of their "real world", the world of pop culture and music videos.

It needs also to be pointed out that stories of many types account for the experiences and explanations of human beings. Often these narratives are understood as historical in the sense that the data is presented in a linear fashion and can only be used in that way. But sometimes the "story" is presented in a way that does not impose a time sequence, nor a strict cause-and-effect scenario. This is much more representative of the disorderliness of everyday existence and of culture, the container of our collective endeavors. This seems to me
to argue for the use of hypermedia and the development of classroom strategies that imitate this disorderly scenario (perhaps in a way that makes it orderly -- but that is another paper!).

If we can use technology to manipulate the mythology that represents the collective experience of students, it might further be possible to use the ordinary rituals of class (e.g., lecture, discussion, question, response) in a way that really engages students in thinking and learning rather than copying and memorizing. This will become clear in my demonstration.

Problems

The question remains of how to develop "classware" that will intrude on the currently-accepted classroom culture (understood as "the way we do things around here"). How can we change the expectations of students regarding their learning? What are the major obstacles to such a task? Part of the difficulty for humanities faculty is that using media simply to disseminate information is not an enhancement since the objective is not just to gather information, but to learn to analyze or think critically about it. That students have virtually no critical-thinking skills when they enter college is clearly a problem to be addressed.

Some critics of the "Information Age" have pointed out that our problem is no longer getting information, but that we have so much we do not know what to do with it all [Dede, Fontana, and White, 1993]. Organizing this information and teaching students how to develop relational models is also problematic. How do we distinguish between information we have to "know" and information that can be "looked up"?

And finally, my experience in teaching the humanities using all sorts of media programming suggests that how I use it is sometimes more important than what it is that I use. This is the most neglected issue in developing "classware": where does the human presenter fit into the program? How should we incorporate the teacher as media into the broader picture of multi-modal presentation? I would argue that technological teaching tools can be very effective in the humanities classroom if a teacher learns how to use them to get a response from the student; and further, how to use them to change expectations about "the way we do things around here.

This "How do I use the technology" in the humanities environment is, perhaps, the most critical issue in the modernization of the university. In some respects the solution is obvious if only faculty in the liberal arts tradition could agree that a liberal education, or education that includes a good dose of humanities is really education in critical or analytic thinking. Further, good teaching is often presented as modeling for student imitation or the exemplification of what thinking is or the simulation of problem solving strategies. All of these things can easily be done using classroom technology and do interactively.

Milton Glick and others points out "that it is not what the teacher does but what he or she gets the students to do that results in learning" [Glick, 1990].

Assumptions

When students come to a University, they bring their educational culture with them -- that is, they come with the certain assumptions and expectations that were ingrained in them through twelve years of "schooling" (not necessarily education). For example, they assume:

1) Education is getting answers to questions;
2) By now, I've heard all the questions that are relevant to me;
3) School is a process in which I do what the teacher wants and get a "good grade" -- i.e., I put in the time and get my reward;
4) I am in college to get a good job;
5) There are some taboos:
   -- never volunteer an answer in class:
      a) you might get it wrong since there are only right and wrong answers;
      b) you might look intelligent to your peers;
      c) you might be branded as trying to get on the "good side" of the teacher;
   -- thinking should never be done in public.
6) There are "socially accepted" ways of doing things:
   -- do the paper the night before it is due (people work best under pressure);
   -- stay up all night to study for the exam (never review on a daily or weekly basis).
7) And finally the most important assumption: that students know what learning is.

This last is the most problematic assumption because it is difficult or impossible to expect that someone who "already knows" can learn. Clearly it is essential to develop strategies that challenge this assumption.

There are also assumptions on the part of educators and these also impact upon the classroom culture. Such beliefs as "technology will replace teachers;" "students have enough technology without getting it in the classroom;" "no one can teach effectively using technology -- it's just a passing fad;" "it's too hard to learn to use technology in teaching;" or "computers are for the scientists" are sometimes mentioned by faculty as if they were absolute truths written in a dogmatic text that the "chosen" have received. I would suggest that the success of some educators in developing useful applications will eventually change even these kinds of cultural assumptions.

**Strategies**

Gerald Bracey suggests that technology has not paid attention to the most recent findings of cognitive psychology: ". . . cognitive psychologists . . . have come to believe that 'metacognition' plays an enormous role in learning. In general, metacognition refers to thinking about your own thinking, regulating it, and directing it according to the changing conditions of your environment [Bracey, 1991]." He continues by pointing out that "Technology often just replicates many poor teaching practices that exist today in countless schools".

This is true. And it will remain true until educators engage in a cooperative search for "appropriate use" of the imaging tools that are now available and find ways of focusing student attention on what they don't know and how their minds work when they learn.

There is sufficient data to suggest that:
1) Learning happens when students are engaged in the material;
2) Students are engaged in the material when they argue and discuss the subject;
3) They argue and discuss the material when they are sufficiently stimulated to be curious;
4) Curiosity is stimulated by effective teaching no matter what the methodology used.

The question becomes, is it possible for educators to capture the attention of our college students, and can this be done by strengthening the classroom culture and manipulating the essential myths and rituals that make it relevant by using multi-media technology and teaching techniques that employ high-tech visuals? I would suggest that if one could disrupt student complacency in the classroom by challenging their assumptions regarding learning, it would be possible to stimulate discussion, curiosity, involvement and even creative thinking.

The use of technology to create an interactive information environment provides what I would call "appropriate use," because it ". . . gives the . . . [teacher] the ability to access and manipulate not just information products (such as text, graphics, video), but information processes as well" [Conway, 1990]. These processes include analysis and critical reading of texts, understanding how thinking itself works, and the ability to examine and challenge unfounded assumptions. If the classroom myth that empowers student expectations about learning does not include these elements, I would suggest that learning cannot take place. I would argue that the appropriate use of technology in the classroom can change "the way we do things around here" and can thereby effect a change in student expectations and learning outcomes.

**Demonstration**

In an effort to use technology to change the classroom culture, I have focused my attention on its use in modeling, illustrating, and demonstrating interesting connections. Let me point out that I use the technology -- it cannot work by itself. I am the choir director, the band leader. "What teachers should do . . . [according to the Caines], is to 'orchestrate complex experiences' for students." "Complex experiences produce better learning . . .
because they become embedded in the student's 'locale' memory system, the 'autobiographical memory' that records one's ongoing life story -- rather than the less efficient rote memory" [Willis, 1991].

To this end, I fit technology into my over-all teaching strategy in the following way:

1) to project an outline of each class;
2) to navigate between ideas, definitions, examples, questions, animated illustrations and video vignettes;
3) to support lecture and questioning and;
4) to stimulate discussion, debate and thoughtful questioning on the part of students.

Let me give you an example of two classroom exercises that I have found useful. This is authored using ToolBook 3.0a (now converted to ToolBook 4.0) and has been part of my Introduction to Religious Studies course for more than eight semesters.

I am beginning to develop ways of testing the effectiveness of learning outcomes in this class, but would offer two anecdotal responses as an indicator that student response is very positive. First, each semester of the last four, two or more students acting independently of each other have asked me why more professors do not use technology to support teaching. Second, since I began to use this technology nine years ago, the number of students who say "We were talking about this question last night, or over dinner, or while we were watching the game last night" has increased and become a common occurrence. It is my sense that if students are talking about the class outside of class, they are really engaged in the subject and are learning.

Bibliography


Multiple Levels of Use of the Web as a Learning Tool

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Abstract: How can the WWW be used as a tool for a social-constructivist approach to learning while at the same time be an object of study in itself? We describe a course we recently participated in, which illustrated the potential of the WWW as a learning tool as well as a learning environment and a learning product.

Introduction

In this paper we briefly describe the context of an innovative course on the topic on-line and distance learning (a senior elective course in educational technology at the University of Twente in The Netherlands, with 30 students, including five who were foreign-exchange students and one who participated in the course from a distance) and give an overview of how the course was organised and experienced. We move from this general overview to a more specific look at how the WWW environment in the course was used as a tool to support social-constructivist learning processes while at the same time being an object of study in itself as a new form of educational media. We also consider issues associated with this communal WWW-based learning experience that must be faced in real settings, such as course-evaluation and student-assessment criteria, and burdensome aspects from the perspectives of both students and the instructor. We conclude with some reflection on the transferability of our approach to other settings, instructors, and types of students. Our overall socially constructed environment can be visited at http://www.to.utwente.nl/ism/online95/campus/campus.html.

Theoretical Background

Jonassen [Jonassen 1995] is among many who urge a re-orientation in both schools and universities toward what can be called a social-constructivist perspective: away from reproduction toward knowledge construction, away from reception toward conversation, away from repetition toward articulation, away from competition toward collaboration, and away from prescription toward reflection. Jonassen further expresses the desired orientations in learning by the cluster of seven concepts: active, constructive, collaborative, intentional, conversational, contextualised, and reflective. Such orientations are increasingly seen as not only cognitively beneficial to the individual but important for the larger society.

In such a re-orientation, technology has a facilitating function, supplying tools and environments with which to think [Jonassen, Campbell & Davidson, 1993] [Scardamalia & Bereiter, 1993/94]. Jonassen associates his seven clusters of social-constructivist constructs with a variety of technologies which he identifies as having particular harmony with the constructs; while some of these are clear to envisage ("conversation" is associated with "computer conferencing" and "NetNews", for example), others are less clear ("active" is associated with "learning environment" and "reflective" is associated with "cognitive tools"). The link to practice is thus only broadly stated.

For the busy instructor, how can such a social-constructivist re-orientation take place, given the realities of large groups of students, limited access to a broad range of tools, and the need to deal with content as well as process? In particular, how can such a re-orientation take place in a university setting, where students are scheduled for a limited number of face-to-face sessions with the instructor, and where the students as well as the instructor have many demands on their time and schedules?
We have experienced an innovative approach to the course design and participation that we believe incorporates Jonassen's seven construct clusters within the constraints of a typical course setting. The key to the re-orientation was the use of the WWW as a learning tool, able to support within one shared environment a wide range of learning activities and of knowledge construction. We described this approach, in both process and product, in the next section.

Description of the Course

The course met in eight two-hour face-to-face sessions, from March to June 1995. In general, the class came together for the face-to-face sessions in a computer room, where each two students shared a computer. All computers ran under Windows, and all were connected to both the LAN and the Internet. On-line learning experiences occurred between each of the face-to-face sessions and formed an integral part of the course. During these on-line learning experiences, the students selected and retrieved, mostly from the Internet, some of their reading materials for the course, conducted discussions and worked cooperatively with others, and generally developed their skills and insights about on-line and distance learning. Each week in the class session, and also on-line, guidance was given by the instructor to the students as to what and how much to do on-line between the class sessions. Most of the on-line sessions used the Internet or involved computer conferencing with the FirstClass system [Soft Arc, 1993] or e-mail contact via a distribution list or ordinary mail.

Self-study, in addition to reflection during and after the on-line activities, involved reading the materials in the textbook and reader assigned for the course and other materials that the students could find on-line and in the library. The reader was completely on-line in a WWW site, and consisted of notes from the instructor and an electronic book that had been written by the students in the 1994 version of the course. The 1994 students had developed their chapters in collaboration with remote specialists. Although accessible through a WWW site, the 1994 student book was designed and developed as linear text (this 1994 student product can be seen at URL http://www.to.utwente.nl/ism/online/intro/intro.htm).

The major project in the course in 1995 involved the students’ expansion of the 1994 course reader, in which each group of two or three students, was responsible for the redesign and extension of one of the current chapters or other component parts of the course book, making use of the capabilities of the WWW environment. Figure 1 and Figure 2 give an impression of the title-page and table of contents of our book.

The Goals of the Course

The implicit goal of the course was to integrate the seven clusters of Jonassen’s social-constructivist constructs of meaningful learning through the way the course was experienced. The explicit goals [Collis, 1995] were:
1. The students will be able to understand and correctly apply vocabulary and concepts relevant to present-day discussions of distance education and on-line learning.
2. The students will be able to find, retrieve and share appropriate resources from the Internet and will understand key aspects of the instrumentation that support this information handling.
3. The students will be able to participate effectively in various types of Computer Mediated Communication (CMC) and to understand key aspects of the instrumentation that supports CMC.
4. The students will be able to work cooperatively with classmates face-to-face as well as with persons they have never met on on-line learning tasks and to understand key aspects of instrumentation that support such cooperation.

5. The students will, through experience and literature, become familiar with major issues, problems, and potentialities for distance education and on-line learning as being discussed by researchers, designers, and practitioners throughout the world relative to
- network services for education;
- the use of the Internet for learning-related purposes;
- CMC in educational contexts;
- various sorts of conferencing as applied to educational contexts;
- on-line cooperative work, learning, and thinking and groupware;
- hybrid environments to support on-line learning; and
- trends and implications for education and training related to distance education and on-line learning.

6. The students will be able to use the Internet as a designer of educational resources by
- cooperating with their classmates on design and execution decisions relating to the WWW site for the class reader;
- using appropriate resources to contribute to the further development of the reader for the on-line learning class by expanding some aspects of it as a WWW page linked to the other pages in the reader.

7. The students will have an informed opinion about the costs, time and technical issues involved in on-line learning as a form of distance education.

Table 1 shows the relationship between Jonassen’s orientations for social-constructivist learning [Jonassen, 1995] and the technologies used in the course:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conferencing/ Discussions</td>
<td>FirstClass/ Minuet (e-mail system)</td>
</tr>
<tr>
<td>Construction of a hyperlinked textbook</td>
<td>WWW-pages/ Internet/ HTML-editor</td>
</tr>
<tr>
<td>Telecommunication with distant students</td>
<td>CUSeeMe/ Minuet (e-mail system)</td>
</tr>
<tr>
<td>Find and studying source materials</td>
<td>Textbook, distribution list, WWW-sited reader and course notes, external WWW-sites for both content and design ideas</td>
</tr>
</tbody>
</table>

Table 1: Social-constructivist activity types and course technologies

Make Learning Public

For students, an important aspect of learning is to carry out assignments. In doing this, they put theory into practice. Usually, however, only the teacher gets to see and read the assignments. Other students usually don’t get to see any work of their peers. This can lead students to the impression that they are making the assignment for the teacher only, and not for themselves and others to learn from.

In our course this was completely different. The students worked in small groups on an assignment to construct and redesign a chapter of a book, making use of the capabilities of the WWW. Not only the teacher could look into their work, but also their fellow students and everybody else who was interested. And the fellow students had to reflect upon each others’ work, with the class as a whole dealing with design decisions such as:
- Should this be a book to read, or a set of pointers to outside resources?
- Should there be consistency in navigation choices among the chapters? What is better for learning?
- Should the learner be guided through the chapters, or given the freedom to explore?

A positive effect of WWW publication of the assignments is that students can learn from each other solutions to comparable problems. Students can also get new ideas for different approaches to similar design assignments. A particular example of this was the issue of structure of the chapters. The students displayed the structures of their chapters in different ways and, more fundamentally, had good reasons for choosing different structures. Figure 3 and 4 show two different structure representations.
Another positive effect of publication is that this can create an extra incentive for the students to perform well. The students realise that they are working together to construct one product (a book to be available on the Internet). Knowing that many persons may be looking into their work, the students will want to show ‘the world’ the quality of the book they constructed.

Relation of Theoretical and Practical Aspects of the Course

The seven concepts of Jonassen formed a theoretical base of this course. As students of the course we perceived these seven concepts as follows:

We experienced the course as being very active, during the work on the assignment and also during the face-to-face sessions. Most of the time everyone was either working at the computer or involved in a class discussion. Besides the face-to-face sessions we also had to work on weekly on-line assignments as well as the major assignment.

An important aspect of the course was to construct knowledge, by integrating new ideas, obtained during group and class discussions, into prior knowledge. We had to use our new knowledge for the making of the assignments, such as looking for sources on the Internet, and designing the WWW-chapters.

Collaboration was a very important part of the course. We were divided into groups of three students each and almost every assignment had to be made together. All these groups then worked together on the same final project, managed by the teacher.

Good collaboration and action can only take place when the conversation and discussions, are very productive. Conversation and discussion were possible during the face-to-face meetings, but also by e-mail, the FirstClass-system and the CUSeeMe-session.

A positive point was that the learning tasks were situated in real-world settings, such as the Internet and the WWW-environment. Also, the topic of the course (on-line and distance learning) was very up-to-date and new for us all. All the students were very interested to learn more about it. Therefore the intrinsic motivation to participate in the course was high.

Reflective learning was also an important aspect of the course. After every face-to-face session an assignment had to be made and every student had to reflect upon other students’ work. We all got comments and new ideas from our fellow students as well as from the teacher.

Evaluation of the Course Design

But the above-mentioned benefits do have consequences. In our opinion the following considerations are important for this and other courses seeking to use a variety of technologies, and particularly the WWW, for a course as a social-constructive experience.

The first consideration has to do with the class size. The class consisted of 30 students. The class shouldn’t be larger than that. When a class is larger it becomes more difficult to have class discussions (on-line or face-to-
face) with the whole group of students. It also becomes more difficult to keep the students on the same track for the book.

A second set of considerations relates to design-guidelines for the collective product. The contents of the chapters must form one whole as a book. And should the layout of the chapters form one whole too, or should the students be free to make their own choices about the best presentation and layout of their chapter? This question still remains. Because of the different opinions and ideas among the groups class sessions were very useful in keeping the students on the same track about the contents of the chapters.

A third consideration is that this course was based on the use of many media and technologies. Therefore it is very important that these media and technologies are available for students and that they function without technical problems. Through the very use of newer technologies such as connections to the Internet, HTML editing and videoconferencing (CUsSeeMe) students experienced time consuming and frustrating problems.

The last consideration is that the teacher is a very important aspect of the course. He/she explains new course content and leads the class discussions. He/she is a central point in the course for the students to go back to in case of problems. And he/she must believe in the social-constructivist philosophy even when it becomes exhausting to manage.

What Next?

In our opinion it is possible to use this approach to course design in other settings. For instance junior-high students or children in upper primary school classes could participate in a world-wide geography lesson where many classes in different countries collaboratively make a WWW-based book about their part of the world. On a smaller scale it is also possible for students in one country to make a book about their city, community, state, province, etc. Not only will students learn more about their own living environment or country, they also will get a chance to gain insight in another part of the world seen through the eyes of peers. The WWW environment supports inter-linkage and the use of visuals in a way that facilitates this sort of collaboration project. It is also possible to use the WWW or an e-mail or computer conferencing environment in a (distance) writing course where future writers can write a book with short stories or poetry together. They learn from each others’ experiences, they learn from the teacher who comments and leads discussions and they get a chance to write a book. As our example shows, students do not have to be at a distance from each other to make use of on-line collaboration tools for social-constructive experiences. In any case we suggest that the structure of the course should not differ too much from the course described above.

The teacher and the class sessions (or real-time equivalents if students really are at a distance) are necessary for collaborative and conversational learning. The teacher leads discussions about various aspects of the collaborative product and is therefore very important in structuring the process of making this product. Furthermore contact, preferably face-to-face, is important to the students; they learn from each others’ experiences. It is possible to make use of this approach in a distance-learning course but technology then would have to compensate for missing aspects such as personal impact of the classroom-teacher and informal contact between students. Technologies for this (for instance a CUsSeeMe or another type of conferencing system) are still somewhat limited in replacing face-to-face interaction.

Another interesting aspect is the possible use of the product of one group of students for the next group of students. For our group of Dutch students not only the content of the course was of interest but even more the WWW as both a learning environment and as an object of study and evaluation. Therefore our final product, the book on the WWW, may be very useful as a learning tool for the next generation of students taking our course, just as we built upon the work of the students from the year before. This may also be the case for the above-mentioned geography book or the short-stories book. But it is of course also possible to have each class start from the beginning and have them create their own book fully according to their own ideas. Afterwards they can compare their work with that of former students. Of course, while making the book, all contributions of other students are interesting because we can learn from each others’ experiences. In our opinion, the WWW environment provides the core tool for this learning setting, both for process and for product.

References


An Interactive Cooperative Teleworking Environment -

Τηλεμαθεία *

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Abstract

In this paper we present the design and the implementation of an interactive environment for cooperative teleworking. Telemathea offers tools that support the communication and the teleworking between tutor and trainee, who may reside in remote geographical regions. This environment offers audio communication over the network as well as support for joint editing of text documents and still images. It supports different audio coding techniques so as to adjust to the available bandwidth, and makes use of the RTP protocol in order to facilitate the exchange of audio and, in the future, video packets.

1 Introduction

Multimedia telematics applications for communication and cooperative teleworking give the opportunity for creative joint-work independently of geographical locations. Applications of this kind provide tutors and trainees with the ability of continual, close and efficient cooperation without any need for transportation and personal meetings. Furthermore, the environments for Computer Supported Cooperative Work (CSCW) may give the opportunity for virtual meetings, conferences and presentations without the limitation of physical presence ([Herzner and Kappe 94]).

Initially a few applications for Remote Expert Consultation were developed that attempted to provide experts with the ability of limited cooperation. An approach to Remote Expert Consultation was RECPHone ([Basirogliou et al. 91]) which was implemented as a part of the European project TELEMED/RACE. The aim of RECPHone was to fulfill the remote doctors' needs for communication and cooperative telediagnosis. RECPHone provides its users with capabilities of transferring files and medical images and interchanging text messages and cursor coordinates in order to attend virtual medical meetings for telediagnosis.

Applications for Remote Expert Consultation have been enhanced with facilities for joint-editing of text files and document conferencing so as to develop environments for cooperative teleworking.

Based on the major principles of RECPHone, Telemathea was developed in order to offer an environment for cooperative teleworking and collaborative learning. Telemathea is a telematics application that aims to answer the needs, of remotely located, tutors and trainees for an open line of communication, interactive conferencing and cooperation. It offers end-to-end communication over networks by using multimedia information handling and interchange ([Minoli and Keinath 94], [Loeb 92]).

Telemathea offers a number of advantages which can be summarized as follows:

- Interactive one-to-one communication, enhanced by audio over the network.

*Τηλεμαθεία (telemathea) is the Greek word which best describes cooperative teletraining.
• Modular design and open architecture. This permits the adaptation of Telemathea, with relatively small effort, so as to use the more advanced facilities of the broadband networks, when they will be widely realized.

• Provision of a shared text and image editor with the ability of document conferencing.

• Ease of use. Telemathea has a user friendly interface that hides from the user most of the network layer details.

Telemathea is an environment that can be put into immediate use over the existing networks, and can greatly aid the implementation and realization of cooperative teleworking and collaborative learning services. This use can offer a number of advantages to the tutors and trainees among which are the following:

• Interactive communication by means of interchanging text and audio messages according to the principles of What I See Is What You See (WISIWYS).

• Capability of real time communication and work with a remotely situated tutor.

• Both tutors and trainees do not suffer from loss of creative time by avoiding useless transportation.

• The use of cooperative teleworking and collaborative learning solves the problem of the limited number of experts and reduces the cost of cooperation among remotely situated individuals.

A general description of the functional model, the major principles of design and implementation and the possible future enhancements will be presented in the following paragraphs.

2 Description

Telemathea has been developed under the Unix operating system and its user interface has been based on the X Window system with the use of the facilities offered by the OSF/Motif ([Rost 90]), Xt toolkit and Xlib. It has been installed and successfully tested on a variety of workstations with 486DX processor, and SCO Unix/SCO Open Server operating system.

2.1 Communication layer

The implementation of the mechanism that manages the network connections needed for the realization of the services offered by Telemathea, is based on the TCP/IP protocol suite ([Comer et al. 93]) and makes use of the client server model([Tanenbaum 89]; [Stevens 92]). The workstations communicate with each other through the use of the socket mechanism, in connection-oriented or connectionless mode of operation and well-known ports.

In order to take advantage of the multitasking capability of the Unix operating system, all the services have been implemented as separate processes. Furthermore, there is a unique process (communication control process) that manages the network connections of the communicating workstations. This solution has been chosen because of the nature of Telemathea, which demands concurrent communication (transmission/reception of different kinds of data and control packets) and management of the graphical user interface. There are two types of packets that are exchanged between the communicating workstations, the control packets and the data packets.

The control packets are exchanged between the communication control processes through a bidirectional network connection. The management of the interaction between the communicating workstations and the joint-editing of text files and still images are performed through these control packets.

Also, a distinct network connection is established for each kind of data packets that have to be exchanged between the communicating workstations. These connections are handled by the process that is responsible for the realization of the corresponding service. Such a connection is active as long as the two workstations communicate by interchanging this kind of information. By using different processes to transmit different kinds of data packets, there is a more effective way of exploiting the available bandwidth and the synchronization of the communicating processes becomes easier.
2.2 Communication modes

There are three different modes of communication between the two counterparts:

**Interactive mode.** It is the most important mode of communication, and it is used when a user desires to have a direct communication with another user. For this mode, a client-server model has been implemented, where the requestor of the communication is the client and the respondent of the request is the server.

**Batch mode.** This mode of communication is used when there is no need for immediate response by the receiver of the message. The communicating process in this case is the following: The sender selects the information to be sent (some data files, or images followed by explanatory textual information and topics for discussion) and after specifying the peer's address he transmits them. The receiver will be notified for the new message as soon as possible and will reply at his own will.

**Mixed mode.** This mode of communication is the combination of the two previously described modes. In this mode the initiator starts a batch mode communication and the receiver is informed immediately for the message. The batch session is followed by an interactive session, provided that the receiver is able to reply immediately.

2.3 Architecture

Telemathea can be divided in two major parts, the local data processing part and the communication part. There is also a minor third part that consists of the modules that interact with the sound drivers for recording and playing back audio messages. The first part deals with the local processing and representation of the data handled by the application (e.g. plain or formatted text, still images and audio), the selection and encoding/decoding of the data that are to be transferred or received, and the storing/retrieving of data files. The second part is responsible for the communication process (session establishment, data transfer over the network, error checking, synchronization, etc.).

More specifically, Telemathea can be divided in several modules that offer a number of facilities, which can be summarized in the following:

**User friendly graphical interface.** Telemathea offers a friendly and easy to learn graphical user interface that provides fast access to the mostly used functions and releases the user from taking unnecessary actions or making improper use of some functions. Also, an on-line help option is provided.

**Local data processing.** This module provides joint-editing of textual information/still images during the conference and the selection of the data to be sent to the other peer of communication.

**Communication.** The processes that are responsible for transmitting/receiving different kinds of data (text, image, audio) are parts of this module. The communication control process is included in this module too. The protocol that describes the principles of the communication between two nodes is implemented here. There is also a trailing procedure that keeps track of the cooperation for the proceedings of the interactive session. This procedure registers the initiating time of each session, the address of the communicating counterpart, the subject, the mode of communication and the main topics of the cooperation.

**Data handling.** This module takes over the storing and retrieval of data used by Telemathea. During the retrieval or the storage of some data files the application takes into account the type of this information (plain/formatted text, still image, audio message) so as to code/decode it properly. This module also keeps track of the session establishments and the data transfers between the two end users, during the conference.

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1"He" should be considered as "he/she" throughout this paper.
2.4 Functional overview of the services offered by Telemathea

The basic aim of Telemathea is to support the interactive cooperation and communication between its users by using multiple media. Communication can take place by means of interchanging textual messages, still images, audio and data files. Also, cooperation can take place by means of joint-editing of text files and still images (document conferencing). The services provided by Telemathea can be summarized in the following topics:

1. Transfer of text files and still images.
2. Interchange of text messages.
3. Audio communication.
4. Joint-editing of text files and still images.

All these services are accessible through a graphical user interface. The communication control process is responsible for the synchronization of Telemathea's operation. Each of the services mentioned above is implemented by one or more separate processes.

2.4.1 Transferring of text and still image files

This service is offered in both interactive and batch mode. When two Telemathea applications communicate in interactive mode, any user can select a set of text and/or still image files and send them to the remote peer. Telemathea supports ordinary ASCII files and GIF and X11-bitmaps for still images. Provided that enough bandwidth is available, the file transfers take place within short time limits. File selection takes place through appropriate windows of the user interface. While a file transfer occurs, the recipient is informed about its progress. The names of the files that have been transferred are shown in a list. Then the recipient can see the contents of any file appearing in this list, at his own will.

The scenario for file transfers in batch mode is the same except that there is not an interactive session in progress during the transfer process. Nevertheless, the remote user will be informed after the completion of the overall procedure.

The Telemathea application uses a file transfer client process that initiates the communication procedure and sends the files, and a file transfer server process that receives the files. These processes implement a variation of the trivial file transfer protocol ([Sollins 92]).

2.4.2 Interchanging text messages

A trivial way for interactive communication between two Telemathea's users is by interchanging text messages. This service is offered only in interactive communication mode when the available bandwidth cannot support audio communication. Provided that both users agree to communicate by text messages, two windows are activated in both user screens. The left window is used for editing and sending messages to the remote user and the right window is used for the representation of the received messages. The communication by interchanging text messages is fully bidirectional and is performed by two separate processes in each workstation. Both the client process (that sends messages) and the server process (that always waits for the remote user's messages) are running simultaneously during the interactive communication session.

2.4.3 Interchanging audio messages

This service is the standard way for the communication of the trainee and the tutor during the interactive mode. The audio stream to be transmitted is coded in a suitable form. Available codings at the current stage are Pulse Code Modulation (PCM), Adaptive Delta PCM (ADPCM), Variable ADPCM (VADPCM).

The audio packets are transmitted with the use of the Real Time Protocol [Schulzrinne et al. 94]. This protocol has the advantage that it offers information which can be used in order to estimate the
Quality of Service. In this way it is possible to automatically select the encoding that fits best for the available bandwidth ([Gong 94], [Gibbs et al. 94]).

The network mechanism consists of two sound servers that reside in each of the communicating workstations. Between the servers a UDP connection is established. The audio stream from each workstation is encoded, broken in RTP packets and delivered to the server, which transmits them as UDP packets to its peer.

The major reasons for the choice of the previously described mechanism are the following:

- UDP is chosen instead of TCP because the error checking and the retransmission mechanisms of TCP introduce unacceptable delays.
- The complementary information provided by RTP enables us to estimate the Quality of Service and accordingly act.

In the case that the available bandwidth is not enough for audio communication of acceptable quality, Telemathea reverts its users to the communication by means of interchanging of text messages.

The audio messages of each interactive session are saved by the trailing procedure and can be replayed at any time by both the communicating counterparts.

2.4.4 Joint-editing of text files and still images

This facility is offered in the interactive mode of communication. It allows the concurrent document processing by adding or making changes on textual information and still images. This service is referred as Joint Editing and Document Conferencing and is a major part of a CSCW tool.

The model used for the communication in this service is the master-slave model, where the roles of the master and the slave are interchanged between the two communicating peers. When one of the two counterparts wants to make some changes in the document, he requires permission to be the master of the conversation. As soon as the other user has completed his changes, the request is satisfied and the roles of master and slave are interchanged. Only the master peer has the right to alter the document, while the slave peer watches the changes on his own screen. The master peer translates the changes into specially formed message packets that describe the modifications on the common document, and sends them to the slave peer. On the other side, the slave peer is responsible for decoding these packets, for presenting the corresponding changes and for updating the local copy of the common document.

Concerning the service of joint-editing of text files, the master peer has the authority to take the following actions:

- Insert text at a point indicated by the cursor.
- Mark a region of text.
- Cut and paste a marked region of text.
- Scroll the text window.
- Move the cursor.

All the changes that the above actions cause to the common document are immediately reflected to the remote peer.

Concerning the service of joint-editing of still images the following actions can be taken by the master peer:

- Insertion of a comment that starts at a selected point of the common image specified by a mouse click.
- Drawing of free shapes and single spots by means of a paint brush.
- Drawing of rectangles by specifying the upper left and the lower right corners.
- Drawing of circles.
3 Conclusions - Future Work

The design and the implementation of Telematheia, an environment for interactive cooperative teleworking and collaborative learning, has been presented. Telematheia can be used over conventional networks as well as high-speed networks and, depending on the available bandwidth, it can support audio communication over the network.

In the future, the joint-editing facility should be augmented so as to support image and text formats of well-known word/still images processing applications (e.g., Microsoft Word, Xpaint, Xfig, etc.). Also, the communication process can be enhanced by video communication, provided that the network infrastructure will be able to support such a facility. Moreover, the communication protocols should be enhanced in order to exploit the characteristics of the broadband networks and especially of mechanisms that are offered by them and provide real-time control of the QoS.

Another future improvement is the integration of Telematheia with other multimedia applications in a unified multimedia applications library and the interaction with distributed Multimedia DBMS’s for the easier access to public, raw, multimedia material.

Finally, the cooperation of more than two persons is a very important point for future work, thus Telematheia must be augmented so as to support multi-personal audio/video conferences and joint-editing.

References


The Harlem Environmental Access Project: A Partnership with Columbia University, The Environmental Defense Fund and the Public Schools of Harlem, New York

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Abstract: This is a discussion about the preliminary research that is underway by the Center for Urban Youth and Technology (CUYT) on a high speed technology-based telecommunications project in Harlem, New York. The Harlem Environmental Access Project (HEAP) is designed to place high speed telecommunications between schools, libraries, Columbia University and the Environmental Defense Fund. The schools will create information content for the Internet and utilize the resources of the collaborating organizations. HEAP is supported by the National Information Infrastructure and is designed to support their goals and mission.

Introduction

The purpose of culture is to empower human expression, and a fully technology-based education will do that: enabling people to use the tools of expression to form conviction, to empower action, to sustain reflection, to nurture hope. [McClintock, 1989]

This is the theme of the Harlem Environmental Access Project’s (HEAP) Principal Investigator, Dr. Robert McClintock when discussing the project. The Harlem Environmental Access Project extends the National Information Infrastructure to connect the information resources and expertise of Columbia University and the Environmental Defense Fund (EDF) with students and teachers in the Harlem Economic Empowerment Zone. Through the extension of existing high-speed networks and the application of powerful, yet easy-to-use, graphical user interfaces for teaching, a broad array of environmental resources will be provided to teachers and students.

This demonstration project will include purchase and installation of new computer facilities for five public schools and one library, the provision of curricular materials and support, and the network connections and equipment necessary for Columbia and EDF staff to participate fully in the project. The six sites include; Mott Hall School, Fredrick Douglas Academy, Walegh School of Science and Technology, The Clara Mohammed School, North View Technology school, and the Countee Cullen Regional Library. A further intention is to make the content developed under the grant available to all users of the Internet. Thus, in addition to extending the National Information Infrastructure, they will significantly increase the environmental resources to which users have access.

This partnership of a major university and a major U. S. environmental organization brings a unique combination of resources to the Environmental Access Project. Incorporating its affiliates, which include Teachers College and Lamont-Doherty Earth Observatory, Columbia University is among the premier research and teaching universities in the world. As part of its mission, Columbia includes outreach to the surrounding neighborhoods of upper Manhattan. The Environmental Defense Fund, a leading national group, addresses many environmental issues of concern to communities, as well as issues of the global environment, through the use of interdisciplinary teams of Ph.D. scientists, economists, and attorneys. EDF has also placed special emphasis on public education involving such issues as lead poisoning, recycling and toxic waste, and global climate change.
Both Columbia and EDF are open to the opportunity to connect with other relevant information infrastructure projects.

The objectives of HEAP focus on the following topics.

• To provide Internet access to schools and libraries in the project,
• To provide environmental data and information to students and teachers in these schools, and
• To connect these school with the expertise and information resources of Columbia and EDF.

Methods and/or Techniques

Formally located at Teacher College, Columbia University, the Center for Urban Youth and Technology (CUYT) at the State University of New York at Albany has been involved in design, implementation, and research about hypertext environments for some time. CUYT is developing research materials to identify the effectiveness of deploying these types of networks in urban centers and the importance of this technology to the community. CUYT is concerned about how effective are hypermedia environments for student learning and what makes it and effective tool for instruction.

Presently, the 18 month demonstration project has selected 5 schools and 1 library in the Harlem Empowerment Zone and is installing equipment and telecommunications capability at each site. Last summer, CUYT was invited to attend a two week workshop for teachers and students from the schools and library that was selected. We conducted some informal interviews with the school administrators, teachers, and students during the workshops to get a sense of their expectations and concerns. From your interviews and observations about the Initial results indicated that the participants were excited about the prospects of this project happening in their facilities. They were extremely interested in watching the process evolve and for the project to succeed.

CUYT is currently conducting a formal evaluation to determine attitudes and responses to this technology by settings up interview sessions with significant participants in the project. These participants will be students, teachers, school administrators, funding staff, and the project principle investigator. We have developed a set of questions to ask and will be gathering that data shortly. This is important consideration for us because it is designed to give us the opportunity to meet all the participants and to hear their interpretations of HEAP and what it’s significance is to them. This also gives CUYT an opportunity to meet the participants in their own environment and to express our commitment to this project. These interviews will tapes so that they can be coded at a later time.

Our initial research questions are: How do students perceive high speed technology in their educational experience? What is the electronic literacy of hypermedia environments as seen by students? Does high speed telecommunications networks influence the learning process for students? We are planning focus groups sessions, a survey about electronic literacy, and site observations to begin to answer these questions. CUYT use the resources of the network to communicate with the schools and the library to demonstrate how this technology can be used as part of our research. We are planning to use the medium to transmit electronic surveys to participants in HEAP. CUYT is also part of the National Research Center for Improving Student Learning and Achievement in English. This collaboration will focus on the electronic literacy aspect of our research to identify attributes of hypermedia environments. This area will be fully developed in future presentations on these topics. This is an on-going project and additional results will be generated to address the research questions that we have proposed.

Results

HEAP has moved from design stage to implementation and the community is now involved in the process. The project has selected 6 sites and received support from the Education Committee of the Harlem Empowerment Zone. The summer training institute has finished with great success. The schools are developing their own web sites and multimedia products. The web sites may projects and content about the schools and environmental material that is relevant to the project. HEAP is training the school personnel in web and multimedia design and then asking them to create the content material. One science teacher is having her students do research on web to support their science projects for the school fair. Another computer coordinator is creating multimedia
products using hypercard and Digital Chisel. The goal is to create electronic books and CD-ROMS for school
activities. The project is moving forward and we will soon see the first results of this collaborative effort.

References

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The Development of a Computer-Mediated Academic Communication System

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Abstract: In an agreement with Apple, Inc., the Kirksville College of Osteopathic Medicine (KCOM) has initiated the development of a computer-mediated academic communication system (ACS) to provide linkage among KCOM faculty, preceptors, and students throughout the education program. The educational model includes two years of instruction on the Kirksville campus and two years of clinical training in community-based hospitals and clinics located in three geographic regions. Students lease Apple PowerBook computers for their use throughout the four-year program. Students use the computers to communicate with their academic advisors, instructors, and classmates and to receive class notes, lecture materials, patient cases, and clinical reports while on the Kirksville campus and on clinical rotations around the country. This paper describes the development of the ACS. This paper also discusses the possibilities of further implementation of this system that might be useful for other academic institutions.

Introduction

The shift in medical education from the traditional model of the tertiary care teaching hospital to community training sites has been difficult. While many reasons are given, the limiting factor appears to be communication between the community-based training site and the traditional tertiary care teaching faculty. Faculty express concerns that student progress, assessment and didactic experiences cannot be adequately handled at training sites away from the basic science and clinical faculty. These concerns are especially critical for our institution since all students spend years three and four of our program off campus at regional training sites. To address this concern the Kirksville College of Osteopathic Medicine has initiated the development of a computer-based communication system to provide linkage among faculty, preceptors, students, and academic offices on our extended campus. In an agreement with Apple, Inc., KCOM students lease Apple PowerBook computers for their use throughout the four-year program. The computers are used for educational instruction, assessment and communication. For these purposes, an Apple computer network was established by using PowerTalk software. This paper describes the development of that network, as well as future uses of the system in linking distant training sites.

Methods

The extended communication features of PowerTalk have become part of the standard user interface on the new operating system of Apple Macintosh computers. With PowerTalk system software, individual users have an integrated suite of communication tools available which offer consistent access to a wide range of electronic communication services, such as sending styled text, graphics, images, QuickTime video clips, and sounds, as well as computer programs and multimedia applications. Since PowerTalk can be used for both server- and non-server-based computer networks, this modality was selected to build the computer-mediated academic communication system. Figure 1 shows the infrastructure of this system.
A PowerPC 8500 Macintosh computer with a 2GB hard drive was used as the file server for the server-based network. Administrative PowerTalk and PowerShare software were installed on this dedicated Macintosh computer. Hubs (10-base-T) were used to connect the server through Ether cable to the computers in classrooms and academic offices on the campus. This server was also routed to a set of twelve Global Village modems. A dedicated 1-800 phone line provided by the local telephone company was connected to these modems.

While students are on campus, they can connect their PowerBook computers to any one of 450 available 10-base-T jack in the classrooms or library to the ACS. While students are at regional training sites or at home, connection to the system can be made through a local phone line or 1-800 number. This network will eventually be extended to each of the three regional training sites. In the future, students will also be able to connect their PowerBook computers to the ACS through one of the proposed regional computer servers.

A PowerTalk Info-Card was first developed and assigned to each of the 131 students in the class of 1997 and 37 related faculty and academic managers. A separate PowerTalk account was then assigned to each of them. The PowerTalk account provides access to the academic communication system and it is also the central location for faculty and students to distribute and receive electronic messages. Directory information, including individual names and local phone numbers of each student and faculty member, is contained in the Info-Card for use in non-server-based communication. Using the internal modem and the Apple Remote Access (ARA) software, students or faculty can dial directly through the computer modem and communicate with others through the non-server-based network at their own cost. Students can also connect their PowerBooks directly to phone lines and dial the 1-800 number anywhere in the United States to communicate with faculty, academic offices, and their classmates through the server-based network.

Gateway software (SMTP Forwarder) was installed on the ACS server. This software ensures students access to traditional e-mail and the InterNet. Internally, the student Info-Card was grouped by class. The grouped Info-Card allows school administrators, academic offices, faculty, student organizations, or individual students to send messages to a selected group or an individual. Faculty and students use their Personal Catalog (a group of individualized Info-Cards) to share messages and instructional materials.

Results

While students are on campus during the first two years of the program, the ACS is utilized to provide instructional material to the student. Since the system can convey images, sounds, QuickTime video clips, as well as computer programs and multimedia instructional applications, patient case presentations were developed by the faculty. These instructional programs and patient cases contain charts, illustrations, clinical photos, slides, and/or text, they are installed on the ACS server for students to access. One program developed for pathology contained QuickTime video clips demonstrating needle biopsy procedures, which would have been impossible
using the transitional e-mail system. In addition to the unique instructional programs developed by the faculty, a variety of commercial medically-related software was purchased. Copyright agreements were reached to allow network versions of programs applicable to biochemistry, pharmacology and anatomy to also be installed on the ACS server.

The most significant impact of the ACS to date has been the effect on communication with students at regional training sites. The class of 1996 was the last class to begin rotations without PowerBook computers. Communication with the Kirksville campus was limited to letters, phone calls or personal visits. With the development of the ACS, e-mail and Power Talk mail became possible. Table 1 summarizes the number of contacts with the Academic Affairs Office by the class of 1996 and the class of 1997 with the addition of the ACS.

<table>
<thead>
<tr>
<th>Contact</th>
<th>Class of 1996</th>
<th>Class of 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter</td>
<td>3,755</td>
<td>3,120</td>
</tr>
<tr>
<td>Phone Call</td>
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</tr>
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<td>12,890</td>
</tr>
<tr>
<td>Total</td>
<td>10,359</td>
<td>26,004</td>
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</table>

Table 1: Comparison of Academic Contacts Between Classes of 1996 and 1997 During The Third-Year Clinical Rotations

Over 12,000 electronic contacts were made by the class of 1997 utilizing the system. Of more importance, however, is the decrease in the number of placed calls and letters during the same time period. Students at regional training sites, as well as students on campus can now access the educational programs on the server and ask questions of basic science and clinical faculty through PowerTalk messages. These local and remote instructional assistance programs were almost impossible in the past.

The ACS has allowed for the development of an automated log system for tracking the clinical experiences of students. In the past this information was provided by handwritten communication that was frequently not legible; it required extensive clerical time to generate meaningful data for analysis. A computer-based log program was developed using Authorware Professional software. This program allows students to record clinical encounters and procedures performed on clinical rotations. Using an automated feature of the program, students can transmit data automatically to the ACS network through the internal modem to KCOM. A log management program was also developed using FileMaker Pro. This program downloads the log reports from the PowerTalk Mailbox into a log database which allows for monitoring of student clinical activities.

Discussion

Our initial experiences with the academic communication system have been very positive. This system has allowed for enhanced communication between students and faculty at all levels of the educational program. The success of this system can be attributed to several factors. PowerTalk is relatively economical and provides tightly integrated computer software that offers consistent access to a wide range of communication services, such as e-mail, fax, and voice messages, as well as styled text, graphics, images, QuickTime video clips, sounds, computer programs, and multimedia instructional applications. PowerTalk is easy to use, and it allows faculty and students to spend more time on academic issues and less time on the technology. PowerTalk communication is extremely flexible and requires no file server when using the AppleTalk network or a modem. This feature allows faculty and students to communicate freely in groups or on a peer-to-peer basis. The PowerTalk Mailbox, Catalog, and Info-Card combination provides a one-stop repository on the desktop that allows faculty and students to manage all their correspondence through a central location. The combination of PowerTalk and PowerShare offers enhanced collaboration features and allows for upgrades of the academic database by individual faculty without compromising file security.

The equivalency of educational experiences in programs conducted at multiple sites is a major concern of our regional campus program. The development of the electronic log program will greatly aid us in assuring equivalency of clinical experiences. The organization of the log program by clinical rotations allows for direct comparison of student clinical experiences by service (rotation) among our regional campuses. This information can be processed to readily identify students who have had subpar experiences and allow for their remediation. The log data can also be used for the development of assessment tools in the evaluation process, another critical area for the regional campus programs.
Several educational programs for this system are now under development for students on the regional campuses. This communication system will allow educational material to be delivered to individual students at different locations. The significance of this capability stems from the fact that at any given time students in the same class may be on a minimum of five different services. Thus the ACS allows for the presentation of educational material specific to a student's rotation regardless of location. This capability will also help ensure equivalency at different sites. Individualized remediation programs for a given rotation can also be delivered to specific students.

There are many features of PowerTalk and the ACS that we have not yet explored. DigiSign could be used for electronic approval and verification of data. This application could be critical in the design for computer-based assessment packages utilized with the ACS. Pager could allow for sending information to multiple destinations. Communication regarding clinical experiences between regional campus students and on-campus students could be used to reinforce learning objectives prior to hands-on experiences; it could also reduce the anxiety of moving from the classroom to the hospital and clinic.

The computer-mediated academic communication system that we have established serves about 500 users. We have not experienced the problems that may arise when serving a large user group. The most common complaint has been busy phone lines, because the system can only handle 12 remote users at a time. This problem should be resolved after each regional training site has been networked with a separate file server.

References


Acknowledgments

Special thanks to all who contributed ideas and support directly or in-directly toward the completion of this project and to Judy Booth and Jeanne Kangas who helped in the preparation of this manuscript. Without them, this project would not be possible.
Abstract: Teachers and schools across the nation are today invited to participate in one of the greatest outpourings of educational technology in the history of public education. Such a great outpouring of technology means nothing, however if it is not accompanied by an equally great outpouring of education. We cannot, that is, have more media in our education without having more education in our media. The battle for educational television forms an important backdrop and raises the important question of whether the educational community will ever harness the powers of technology. The author proposes a way to break through the confusion and conflicts over educational television and point us towards a new world of cooperation in which we all—parents, teachers and broadcasters—speak the same language.

Over a hundred years ago, facing a world of radical and tumultuous change, Mathew Arnold calmly noted: “Come to the window. Sweet is the night air.” [Arnold 1867] For as Arnold looked out upon the cliffs of Dover, he undoubtedly felt much as we do today, standing as on a broad cultural plain wracked by incredible social and political revolutions. The vast innovative sea of technology lies before us as, in his words, “a land of dreams, so various, so beautiful, so new.” The tide is full and the moon lies fair on our educational shores. President Clinton has proposed a two billion dollar Technology Literacy Challenge to hook every school and library to the internet by the year 2000. In California we recently celebrated Net Day, a cooperative effort of companies and schools in wiring hundreds of our classrooms. The governors, in turn, at their National Education Summit last March, formed new alliances with high tech firms and are now pressing hard for more technology in the schools. Congress, in the meantime, has just passed the Telecommunications Act of the century, promising to unleash a whirlwind of competition and technological wonders. All the various CD-roms, lasers, bivisualizations, and 3-D galleries we see before us today are but shadowy enticements to a brighter, more dynamic future for education.

“But, ah, love, let us be true to one another.” said Mathew Arnold as he suddenly recoiled from his scene. And we too may sense his apprehension; for such a great outpouring of technology means nothing today if it is not accompanied by an equally great outpouring of education. We cannot have more media in our education without having more education in our media. We as educators cannot, that is, play the gracious host to a widening array of new devices, programs, and networks unless education itself has a greater influence over the vast array of video games, television sitcoms, and cartoons now being broadcast across the commercial airways.

Today we think of computers and the internet as an antidote, a powerful counter-insurgent force that will ultimately undermining the mass mentality of broadcast television. In the words of George Gilder, “Over the next decade computer networks will expand their bandwidth by factors of thousands and reconstruct the entire US economy in their image. TV will expire and transpire into a new cornucopia of choice and empowerment...video culture will transcend its current mass-media doldrums...Hollywood and Wall Street will totter and diffuse to all points of the nation and the globe...The most deprived ghetto child in the most blighted project will gain educational opportunities exceeding those of today’s suburban preppie.” [Gilder, 1994] But as Kline and Burstein suggest in response to Gilder, the reality is less sanguine. “Rather than being shunted to the periphery of power by the decentralizing effects of digital technology,” they argue, “a merger-mad Hollywood and Wall Street are becoming more powerful than ever in the funding and commercialization of new digital products and services. Mass media television, rather than expiring of its own banality, is increasing in both influence and profitability...” [Kline and Burstein, 1996] AT&T, for example, has offered to hook schools up to
its powerful network for free and many schools are rightfully excited about the prospects. But AT&T is also expanding its alliances to major cable and entertainment companies such as TCI, the nation’s largest cable provider which itself has alliances with the world’s largest entertainment conglomerate, Time Warner. Megamedia deals are growing in global popularity: twenty-five large telecommunications companies, for example, including AT&T, GTE, British Telecom, Deutsche Telekom, France Telecom, IBM, and Microsoft recently announced the formation a “Multimedia Services Affiliates Forum” which plans to improve links across their worldwide multimedia software applications. [Valmasse 1996]

All such corporations are experimenting with their hottest venues: entertainment on demand and interactive shopping malls, neither of which bode well for the learning process of American youth. As the columnist Frank Beacham recently complained about AT&T’s internet access: “AT&T becomes your guide, providing special software... reviews, recommendations, suggested sites to go to....” while also offering a specialized credit card guaranteed against forgery. With AT&T at the internet helm, according to Beecham, “the participatory and democratic model of the internet starts to become more like the broadcast model with the user as a customer, not a participant.” [Beecham 1996]

Similar mergers and alliances are being planned throughout the telecommunications industry and, in the process, the course of the future is being mapped: television and media conglomerates merging with cable and telephone companies who merge with software and computer companies who all then converge in the classrooms of the future. Thus any serious discussion of the internet and its benefit to education must begin on a much broader plane of inquiry, one which will lead us not only to a deeper understanding of the dominant media conglomerates and their historic response to public interest issues, but also towards a truer reconciliation of television—whether it be on cable, satellite, wireless, or the internet—and the goals of education.

The idea that broadcasting and mass media have a responsibility to viewers, and especially to children, and that this responsibility is specifically educational is as old as broadcasting itself. In the early 1930s among the earliest of pioneers of the new technology, the National Committee on Education by Radio, (NCER) struggled valiantly to have the new technology reserved at least in part for educational purposes. At the time, the non-profit educational community, the very ones who had introduced the new radio waves to the public were forced to surrender their stations one by one for lack of funds or government policies to the burgeoning new commercial networks eager to exploit the new wide ranging technology. [McChesney 1994]

Joy Elmer Morgan, one of the founders of NCER, was alarmed: “We are dealing here with one of the most crucial issues ever presented to civilization at any time in its entire history.” The NCER went on to push for the government to set aside 15% of the radio frequencies for educational broadcasting. But the National Association of Broadcasters (NAB) greeted such ideas with disdain and their trade magazine, Broadcasting described the NCER as “a group of misguided pedagogues” with “silly demands.” Morgan in turn accused the NAB and commercial broadcasters of “doing all they can to wreck the educational stations.” After years seeking cooperation with commercial broadcasters, Morgan conceded, “That practice had been tried for nearly a decade and has proved unworkable. It is no longer open to discussion.” [McChesney 1994] Despite his pioneering efforts and courageous battle in defense of education, Joe Elmer Morgan was finally wrong. Cooperation, I will argue, is still the only viable alternative to bridging the gap between education and television. I speak with a special urgency calling on the government, the telecommunications industry, parents, and schools to re-open the public debate and rekindle the search for true cooperation.

Although Morgan and the NCER were eventual defeated by commercial interests, the idea that broadcasters still have a public responsibility survived and eventually became a major compromise of the Communications Act of 1934. In exchange for their use of the public airways, broadcasters had a special responsibility to serve “the interest, convenience, and necessity” of the public. A licensing system was thus created with a new Federal Communication Commission to implement this contract between broadcasters and the public. But neither a structure nor incentives were created to define just how the FCC was to accomplish its task. Under strong commercial pressure the official hand gradually tipped towards a lassie-faire, non-regulated, market-driven, approach. As early as 1935 the FCC claimed that it could not take a station’s programming into consideration when license renewal applications were reviewed. Nor was it willing to do anything that could be construed as censorship.
Lacking any manageable way to enforce this public interest clause, members of Congress and the FCC were left with little to do but remonstrate against the encroaching “wilderness.” [Minnow, 1995] What occurred over the years may be dubbed the period of the “Great Educational Exclusion,” a series of regulations that could never clearly define educational expectations of the networks, and so tacitly excluded educational interests from the airways. The few inroads education ever made on the airways—showcases of classical arts, children’s theater, live orchestras, in-depth analysis—gradually succumbed to the encroaching commercial wilderness. These early years of television reveal a medium that had yet to discover itself, one in fact that looked to the educational model for leadership and focus. But by the 1960s, television broadcasters became infatuated with entertainment as a tool for winning mass audience appeal. The search for the lowest common denominator was on and education was left to fend for itself. seemingly as a last resort and amidst heightening public alarm Congress eventually created the Public Broadcasting Act of 1967, signed by President Lyndon Johnson. Education had finally found a crevice on the airways, a narrow passage through which it could now reach the minds of American children.

In the ensuing decades, however, educators began to realize that on the broader plains of commercial television, still the number one focal point for children, a contagion had spread for which they had few defenses. By the 1980s an increasingly deregulated industry had made some decisive victories vis-à-vis education, the most noticeable being the sheer number of hours television was consuming of a child’s day, over 26 hours a week for 6-11 year olds, that is, significantly more time than spent on schooling. [Neilsen 1992] But television dominates more than a child’s time. It assumes the characteristics of the cultural landscape around it, replacing narratives with its own stories, concocting its own heroes, fabricating its own legends, defining its own grammatical rules. As Senator Bill Bradley recently observed, “At a time when harassed parents spend less with their children, they’ve ceded to television more and more the all important role of story telling which is essential to the formation of the moral education that sustains a civil society.” [Bradley 1995]

David Marc has argued that, even if television is single-mindedly commercial, it “leaves behind a body of dreams that is, to a large extent, the culture we live in.” And his conclusion is enough to set a teacher’s teeth on edge: Television, he asserts, not education, is the “most effective purveyor of language, image, and narrative in American culture.” [Marc, 1992] To George Gerbner, the power of television is even more extensive. Writing in the Journal of Communication he notes that, “Television provides, perhaps for the first time since pre-industrial religion, a strong cultural link, a shared daily ritual of highly compelling and informative content...” In the process, television expropriates the terms and structures of education for its own purposes. Thus to some the television commercial becomes “the sonnet form of the twentieth century...” [Marsden, 1990] Others see the effects of heavy television viewing more apparent in the decline of our language. According to Harper’s magazine the written vocabulary of the average 6-14 year old child in the United States has shrunk from 25,000 words to 10,000 words in less than 50 years. [Harper’s 1994] Leon Botstein also suggests that television’s “simplification and standardization of language...restricts the range of expression and thought, even silent internal rumination. In this sense, eloquence and even originality, from the perspective of the classroom have become superfluous...The oral tradition has triumphed over the written.” [Botstein 1992] Professor Lois DeBakey at Baylor University echoes the concern: “What we are creating is a kind of semiliteracy—a breakdown in the way we communicate with one another.”[DeBakey 1993]

The growing tide of research on the negative effects of television finally reached national momentum in the late 80s and early 90s with reports from the National Institute of Mental Health, The American Psychological Association, and the US Surgeon General, all agreeing that television had assumed a troubling and pervasive influence on American youth. [Mediascope 1996] Consequently, under the leadership of Representative Edward Markey and Senator Paul Simon, Congress once more moved to articulate the claims of education by passing the Children’s Television Act of 1990, urging broadcasters to heed their responsibility to the “educational and informational needs of children.” The FCC began enforcing the Act by requesting that all licensees submit a list of programs that meet the new mandate before their licensees were renewed, only to find two years later in a study by Professor Kunkel of the University of California at Santa Barbara, that few if any broadcasters had taken the law seriously and were listing cartoons such as The Flintstones and GI Joe as educational... [Kunkel 1992]
On April 7, 1995, reluctantly agreeing with Professor Kunkel, the Federal Communications Commission took a new tack when they released a "Notice of Proposed Rule Making," in effect, calling on the American public to help break the spell of inertia that had so long enveloped the children’s television debate. They also admitted that educational programming had now declined to less than one hour a week on most television stations. [FCC 1994] The results were impressive: thousands of parents, students, teachers, school districts, churches, child advocacy groups, psychologists, PTA groups, broadcasters, and President Clinton all participated in what soon became known as the “Kids’ TV Debate,” a debate that promised to remedy sixty years of inaction, a debate, nonetheless, that was seemingly censored on national broadcasting.

From the beginning of the debate, however, the FCC established a basic framework for its discussion, a model of the relationship between broadcasters and the public which, unfortunately, excluded cooperation as a possible solution. The model they developed was that of consumer protection where the needs of children and parents were re-cast into those of consumers. Instead of cooperation, the relationship became antagonistic with each participant pursuing their own disparate goals. Broadcasters want profits; parents want education; neither share a common purpose. Thus to remedy the situation, parents must be given the weapons and ammunition to countervail, restrict, or out-fox broadcasters who must, as the National Association of Broadcasters insisted, maintain their First Amendment rights and unlimited freedom to pursue their own aims. [NAB 1995] In establishing their model, the FCC created a major road block to the development of mutual concerns. Proposals now before the FCC such as the labeling of educational programs hope to arm the public with information rather than solicit cooperation, much as the V-Chip, now an enforceable part of the Telecommunications Act of 1996, relies on parental censorship.

Rather than empowering parents with control over their cultural environment, such solutions as the V-Chip place parents in direct conflict with their culture. And with this new shift of power—“putting the remote control back in the hands of the parents,” as President Clinton has said—the battle for children’s educational programming loses two of its most important and potential allies: government and broadcasters. [Clinton, 1995] The V-Chip is clearly a stop-gap, techno-legal solution that pits the parent against powerful conglomerates of the entertainment industry and the persuasive forces popular culture. Parents are also disarmed by the V-Chip due to the inherent paradox of censorship which, in essence, wets the appetite for the very item—movie, rock song, book, girl friend, or religion—one seeks to ban. A voluntary study conducted by Mediascope, Inc. for the broadcasting industry recently confirmed just this point: that rating systems tend to encourage, rather than discourage, viewing of restricted material. [Mediascope 1996]

Throughout the Kids’ TV Debate many child advocacy groups such as the Center for Media Education and the national PTA also demanded a form of censorship, asking that the FCC set clear quantitative and qualitative standards. The FCC should, they argued, require broadcasters to produce at least one hour a day of educational programming. [CME 1995] Neither addressed, however, the perplexing questions as to how such standards could ever survive a First Amendment challenge from broadcasting, or who would define “educational” programming, or how children would really benefit from only one hour a day of questionable programming, or whether children would even watch programs labeled “educational..,” especially if they were aired at the periphery of prime time viewing. And while the FCC intended to respond to the debate with a final decision in early 1996, it is now doubtful that they have either the time or desire to go beyond the V-Chip, leaving the Children’s Television Act of 1990 still unendorsed and the issues still unresolved.

In the light of these continuing conflicts, we may conclude that the refusal to seek cooperation is the single and most significant impediment to achieving a viable solution. The current Secretary of Education, Richard W. Riley, nonetheless still urges cooperation in solving the nation’s educational crisis, suggesting that schools, communities, businesses, and state and federal governments should work together to support families. [Riley 1996] Families and communities, in other words, must continue to rally the FCC, the Congress, our President, and local broadcasters to seek cooperation.

What would cooperation look like through this new lens of cooperation? How would broadcasters live up to their responsibilities under the Children’s Television Act without, that is, impinging on their First Amendment rights? A few cable broadcasters have already begun answering that question with such cooperative
programming as the “CNN Newsroom,” which provides supplemental video footage, on-line data bases, and study guides to coordinate with classroom textbooks and lessons. Numerous other programs throughout the decades have shown us that education and television can work together. Most recently, the Center for Research on the Influences of Television on Children at the University of Kansas has confirmed that television can truly teach and in the finest sense of the word. In their study, one of the most extensive ever done on children’s programming, they concluded that “Sesame Street” significantly increases word knowledge, vocabulary, mathematics, and general school readiness. On the other hand, children who were heavy viewers of cartoons and adult programming performed more poorly. [CRITC 1995]

In such cases cooperation occurs when the broadcasters join with real educators and begin to speak a common language. In the world of diplomacy and business negotiations it is generally conceded that success is unlikely without a common language. This is also self-evident throughout the educational community: children thrive when teachers and parents share a common language. Thus if broadcasters legally and contractually share with teachers an educational mandate they should speak a common tongue, that is the language of education. Sharing the terms of educational discourse, the grammar of implementation, the same syntax of assessment, broadcasters will more easily integrate their educational mission with that of the schools. At the recent National Summit on Education, for example, one of the key terms that the governors and businesses have begun to share is the term “standards.” Any educational mission becomes a charade without standards. We only need ask that the broadcasters share in the same language in evaluating their educational mission.

Although national standards in education have been in existence since in 1954 the movement to set “world class” academic standards began when President Bush and the nation’s governors met in Charlottesville, Virginia in 1989. The result of their meeting was the Goals 2000: Educate America Act. It called for cooperation among parents, businesses, schools, and state agencies. Among its most important accomplishments was the creation of a National Education Standards and Improvement Council which disburses funds to states to create their own academic standards. The editors of Education Week recently reported that “Republican and Democratic Administrations and governors on both sides of the aisles have embraced the need for standards in education. Government officials at the state and federal levels have passed legislation, created structures, and allocated funds to facilitate the standards-setting process. And parents and tax payers have voiced strong support for the idea.” [Education Week, 1994]

Whether broadcasters utilize national or local standards, how these standards will be integrate into their programming, what assessment device will be used, and how broadcasters intend to inform the public, remain relatively minor when broadcasters accept and act upon the obvious: their educational mandate will remain unfulfilled unless they enter into cooperative alliances with educators and begin to speak a common tongue.
A Multimedia Training Tool For Speech Impaired Clients

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Abstract: Articulator is a multimedia system for use by speech therapists to assist in the rehabilitation of motor impaired patients. These may be stroke victims who have to relearn the ability to communicate effectively. The process is laborious and usually conducted in a one-to-one situation where interaction between therapist and client depends on visual and audio cues. Instead of the usual paper-based prompts used by the therapist, this new system offers screen prompts together with high quality digitised speech. The result is a reduced work load for the therapist. The system is currently undergoing beta tests in Western Australia.

Introduction

Cardiovascular accidents are the third largest killer in Australia after heart disease and cancer. Those that survive this trauma usually have need for rehabilitation. Motor impairment of the speech organ is a common occurrence. There is a worldwide shortage of speech training services to accommodate the clients who require speech therapy. We have produced a Multimedia system which replaces the chart and paper-based cues found in most speech therapy units. The aim is to assist speech therapists by decreasing the time they have to spend in direct contact with patients. More importantly, there are also a number of benefits to clients and these will be discussed later. The system is currently undergoing beta testing in Western Australia and has been acknowledged by the Institute of Electrical Engineers in London after being short listed in an international competition in 1994.

Motor Impaired Client Categories

A Stroke or Cerebrovascular accident (C.V.A) occurs when the oxygen supply to the brain is blocked or when an artery in the brain is ruptured. The former is the result of a clot travelling to the brain and occluding blood flow in a cerebral artery [see Hewer & Wade 1986]. Once the oxygen supply has ceased, hydrogen ions propagate within the brain cells and damage the cells. Within four to eight minutes, the cells begin to die, and of course this destruction is irreversible. In the case of a reduced blood flow, cells may stop functioning but later recover when normal perfusion is restored [see Kaplan & Stamler 1983].

Cardiovascular accidents are the third largest killer in Australia and in many other countries of the western world. The highest killer is heart disease followed by cancer [see Gross 1991]. Fifteen percent of people over the age of forty living in the western world die of cardiovascular accidents. A further fifteen percent are also stroke
victims who survive and require some form of rehabilitation [see Hird 1987]. Of this group five percent make a full recovery whilst ten percent suffer some permanent disability [see Dyken et al. 1984].

As medical technologies have improved and the relative death rate has fallen, so the need to offer suitable rehabilitation services to the victims who have survived this trauma has increased. Patients are left with multiple disabilities and these often include loss of speech. The anterior portion of the brain is associated with speech production and damage to this area can result in motor speech disorders [see Darley et al. 1975]. The severity of the motor speech disorder may vary from person to person but where spontaneous recovery is evident, some speech rehabilitation will probably be carried out. In the case of more severe speech impairment, long term rehabilitation may result [see Gloag 1985]. In most instances, the road to recovery is long and difficult, placing stress on both client and therapist. Any means that may assist this load for both the client and the therapist should be investigated.

Conventional Therapy

In a conventional setting, the client is presented with a number of cues which include symbols representing phonemes/vowels, drawings indicating air flow through the mouth and nose and the many combinations of lip, teeth and tongue positions which are essential in general articulate speech [see Fig. 1]. The therapist is under pressure to find the correct flash card or phoneme chart as she sits with the client. Together with these paper-based cues she uses her own speech and face to offer sound and visual cues to the client. In order the produce the consonant M for example, the client may be asked to place the lips together and allow the air to flow through the nasal cavity. The therapist will give an example by producing the sound herself and simultaneously accentuate the positioning of the lips.

Figure 1. A Typical Paper-Based Chart Used By Speech Therapists

The client is then asked to repeat this step. Consonant and consonant/vowel combinations such as this need constant repetition by the client and consequently the therapist before any improvement is expected (Table 1). This face-to-face contact can be very tiring for both the client and the therapist. As therapy is done on a one to one basis, duration of contact per individual per week may be limited to only a few hours. Clients are therefore being deprived of the continuous training which would benefit their rehabilitation.
Table 1 Consonant/Vowel Combinations With Links To Actual Words

The Computer-Based Therapy System

The concept of a system to assist in speech therapy resulted from consultation with speech therapists in Australia and in the United Kingdom [see Calder et al. 1987]. The development of Articulator depended on a requirement to address some of the above problems associated with conventional therapy methods. The Department of Speech Pathology at the Royal Perth (Rehabilitation) Hospital was involved in the development of the system and provided the old model of operations from which the computer-based system was developed.

The Articulator system aims to relieve constant therapist/patient supervision, particularly where time consuming repetitive tasks are involved. Therapists can use their time more effectively in planning new goals whilst the computer provides visual and sound cues to the client. Therapists no longer have to organise cue cards or sort through hundreds of icons and drawings. These were seldom in colour whereas the computer-based system augments these traditional methods by using colour and animation. The latter was something that could not be achieved on loose pieces of paper or cardboard! Consequently the therapy process can run more smoothly and effectively as all cues are presented on the screen and/or produced by the high quality stored speech system.

There are a number of other benefits which particularly relate to patients and have been highlighted during beta testing. It has been found that the system could be used at home as well as in the conventional environment of the speech therapy unit. Where a client is left with the computer and removed from the clinical surroundings, the stress of embarrassment is removed. This is particularly evident when an older client has to "relearn how to speak" in the presence and under the direction of a young speech therapist. The stress placed on the client during these encounters should be seriously considered.

Another bonus for the system is that it is based on a standard IBM PC or compatible and could even be run from a portable computer mounted to a wheelchair. Most households now have a Personal Computer with a sound board. This means that in many instances, only the software need be installed in the home to allow therapy to continue. Other members of the family could be involved in the rehabilitation and the clinical sessions at the hospital could be used for the monitoring of progress and not be associated with intrusion into the privacy of the patient [see Alkalay & Asserman 1983]. Communication within the family is an important part of rehabilitation and Articulator could help in promoting this. The high cost of therapy is relieved but not replaced by this augmentative system [see Seidl 1977].

Since the Articulator system saves clinician time, it may also help relieve the shortage of speech therapy services. If the amount of time spent with each client is reduced, the clinician could then take on a greater case load.

The nature of a computer-based system is that, "it doesn't have to see another patient in an hours' time". Therefore clients may train at their own pace under no stress. Sound and visual cues may be repeated over and over again without the pressure of supervision. Of course not all patients would be suitable candidates for this level of freedom but initial tests have indicated great success for certain motor impaired victims.
The Interactive System Layout

Multimedia Toolbook has been used to develop this system. It operates in a high level, Windows-based programming environment. It uses a non procedural, object-oriented approach [see Poor 1992]. Toolbook uses a book metaphor for multi screen production. Each screen is described as a page and all pages in a production are called a book. Making use of these properties pages were constructed to emulate the icons and visual cues used in conventional therapy [see Fig. 2].

Figure 2. An Interactive Screen Display From Articulator

Cutaways of the head using colour and animation were added to the standard set of cues. High quality digitised speech was recorded from a practicing speech therapist so that an exact representation of a set of speech sounds could be achieved. As the normal therapy session involves a progressive set of prompts to initiate speech from the client, Articulator was set up with a progressive set of cue buttons which progressively give more and more assistance to the client in achieving a particular goal. For example, this might be help in pronouncing the consonant F. A set of six cue buttons mounted vertically on the right hand side of the screen allow for this positive reinforcement. These cues may take visual or spoken form.

The sound cues may be both instructive and exemplary. One cue button will produce an instruction such as, "place the lower lip against your upper front teeth and blow" whilst another produces the target as required, the actual sound "fff ....". Another button links the consonant to a word so as to place the target sound in context. Yet another offers the word in the context of a sentence.

All cue buttons and command buttons have explanatory logos which appear at the bottom of the screen when the cursor moves over their area. There are over 300 digitised sound recordings associated with Articulator.

The system is normally controlled by a mouse and test models incorporate this means of user control. Other remote switch devices are currently being investigated. This will make the system more versatile and therefore suitable for quadriplegics [see Vanderheiden & Lloyd 1986]. A system of this type should be flexible enough to adapt to suit the needs of each individual client and varying physical disabilities [see Reichle et al. 1991].

The Microsoft Windows graphics environment enables good quality screen graphics to be presented. The graphics within the system consist of 256 colours and a 640 by 480 resolution. Due to the hardware independence of MS Windows, different resolutions and colours can also be achieved according to the setup of the system. The VGA mode is recommended.
Research by the authors has established that phoneme synthesis is not suitable for the speech requirements of this system. A robotic sounding voice may be acceptable for certain games programs and simple communication tools but can never be adequate for the variety of accents, languages and key sounds that may be required by therapists. The Institution of Electrical and Electronics Engineers [see IEEE 1969], published a recommended practice for speech quality measurements in 1969, but this has never been fully adopted as the basis for standardised testing [see Edwards 1991]. Edwards showed that no existing rule-based synthesiser came close to passing the test of being indistinguishable from natural speech.

Linear predictive coding techniques may be used in future in order to conserve memory. The present system uses the Microsoft Windows sound recorder in order to achieve the required quality. Natural voice sounds were digitised at 11KHz. The standard Soundblaster card can be used if the clients' computer does not have a sound card.

The system is currently being tested on a number of patients in Australia. Initial tests at the Royal Perth Hospital have indicated that the response to the system for middle age stroke victims was very positive. Other age groups including children are currently under observation. The interface has proved easy to understand and these patients have managed to control the system themselves, i.e. choosing and activating cue buttons. The tests will also be run in Britain in the near future.

Conclusion

Articulator is a multimedia-based training tool for use by speech therapists and their clients. It is currently being tested in Western Australia and has been acknowledged by a number of speech therapy centres in the United Kingdom. It is specifically aimed at people with motor speech disorders but interest has been shown by groups who work with young cerebral palsy victims. It is believed that it may, in time, be developed into a range of products which may incorporate language learning tools for pronunciation aimed at foreign language clients in particular. The immediate aim is to market this system as originally intended and allow development to progress accordingly.

References


Abstract: One of the truisms in HCI states that users build some form of mental model of the device they are using in order for them to understand the system's application domain. And that the flexibility implied by hypermedia's browsing capabilities has to be conceived in a way that encourages the user's individual learning patterns, that facilitates the development of a conceptual map of the application domain by the user of the system. The underlying assumption is that the clearer the map the user is prompted to form, the more capable the user will be at grasping the application domain.

This truism has been tested by examining the influence of different types of cues on the user's navigation through a hypermedia application. This analysis will be preceded by a theoretical discussion on the nature of and on the reason for mental models in hypermedia design.

Introduction

From the standpoint of the cognitive engineer there is one main parameter to concentrate upon when assessing the quality of any hypermedia application, especially if educationally oriented, i.e., its design, its interface design.

From architectural to industrial, from electronical to handicraft, the history of design is populated by everyday objects which have been blindly projected and badly realized and which have thus failed in improving people's everyday life. Here, improving is considered in its double connotation, both in the sense of making life better and of making life easier. Think, for instance, of the slide projector developed by Leitz Pradovit. There, only one button, i.e., button #7, is provided to interchange slides, but with no specification of its peculiar function. Nowhere, not on the button itself, not somewhere else on the projector, it is explained that the button in question has to be used both to move the slide file store forwards and backwards, with disastrous consequences occurring to the unexperienced user. It is indeed not so frequent that by an absent-minded pressure of the above mentioned button the slide file store accidentally slides out of the projector instead of proceeding forward as in the user's intention. The reason for such an accident can only be found in the instruction manual: button #7 causes the slide file store to move forward when pressed shortly and to withdraw when pressed longer. Would one have thought of such an occurrence without reading the instruction manual? Probably no. And even though such a mention is inevitably necessary, it is in itself not sufficient, as the high frequency of the previously described mistake shows [Norman 1988].

The obvious conclusion that has to be drawn from this example is that the design of any manufactured object must be goal-oriented. And since its primary goal is to improve one's everyday life, it must then be user-oriented. In the field of hypermedia applications such a user-orientedness is reflected in the interface layout. This approach entails a view on hypermedia design as no longer a mere collection of new technology tools, but as a technique to match user requirements. And, as such, it seems in line with the human-computer interaction metaphor underlying the hypermedia framework. The still dominant direct manipulation metaphor [Shneiderman 1988] namely requires the user to initiate all tasks explicitly and to monitor all events. It entails a strict definition of what can eventually be identified as the determinants of effective learning: rather than driving the course of learning by explicit models of both the users' and the system's state of knowledge, effective learning is only achieved by allowing users maximum freedom to explore information bases, to discover relationships by themselves, and to form integrated structures as their learning goals demand [Hammond 1993]. But, as such, it does not seem able to explain how untrained users can possibly interact with a machine effectively. Whereas the emerging metaphor, the so-called indirect management metaphor [Maes 1994], conceives dialogue as an engaging co-operative process between a user and a computerized agent, who are both initializing communication, monitoring events, and performing tasks. Such an agent is not necessarily an
interface between the application and the user, but it behaves as a sort of personal assistant co-operating with the user in the same working environment, by serving as a go-between within the user-system dialogue. It then presupposes the claim to mental models. And a new bunch of quality evaluation principles in the process of creating an interface.

Interface Designing: The Human Interaction Paradigm

"People not technology have become the focus of current interface design" [Norman & Draper 1986].

In the 90s there has been a change of focus in interface design, mainly due to a shift in HCI modelling towards cognitive issues centered on learning and using systems [Laurel 1991]. The way of conceiving human-computer activity deeply influences interface design, loading the interface with responsibility for all aspects of a person's experience with a computer -either sensitive, cognitive, and emotional. That is the reason why what is considered to be the classical approach to interactive computing has now proved to be obsolete. Classically, the interaction is thought of in terms of an application and of an interface, which is typically designed only after the application has been throughly conceived, and sometimes even implemented. They are thought of as two conceptually distinct entities: while the application provides specific functionalities for specific goals, the interface represents those functionalities to people. The interface is actually what we communicate with, what mediates between us, the users, and the inner workings of the machine by being attached to a preexisting bundle of functionalities and by serving as their contact surface [Baecker & Buxton 1987]. Such a view has recently been rejected because it does not really consider the person as a whole, with certain behaviours that are actually constrained by present interfaces, nor even does it overcome that sense of indirection due to the need to "figure out" and to "negotiate with" interfaces which indeed distracts users [Brennan 1990]. The first step in user interface design must then consist in understanding human interaction per se, focusing on its essence (what its purpose might be). The function of the interface is then to present something -a representation, a context- which allows the user to interact coherently with the underlying application by being engaged in its mimetic environment. This statement implies at least one ultimate consequence: that the classical use of metaphors in building interfaces becomes obsolete.

Are Mental Models Adequate Interface Metaphors?

The notion of employing metaphors as a basis for interface design has partially replaced the notion of a computer as a tool [Laurel 1986] with the idea of the computer as the representer of a virtual world in which a person can interact more or less directly with the representation. In other words, for a system to be usable, the user must develop a mental model, or a conceptual understanding of how the system works. This conceptual model can obviously be built by analogy drawing upon knowledge one already has, i.e., by using metaphors. The "desktop metaphor" is in this respect the leading example of this approach, where windows, desktops, and the idea of direct manipulation are predominant elements, as in systems like the Xerox STAR and the Apple Macintosh. Certainly, the shift towards the notion of computers as representers of virtual worlds is a step further in the right direction from the perspective of mimetic interaction. But metaphors have limited usefulness, they are never precise and can mislead. Consider the "desktop metaphor" once more. The beginner has to be told that the curious clutter called desktop, despite the fact that there is no resemblance at all with a real one, is indeed standing for it [Nelson 1990]. The problem with interface metaphors is that they are not ordinary metaphors, but that they are like reality only different and that we do not know how they are different. While a metaphor posits that one thing is another, interface metaphors are similes [Erickson 1990]: they simply assert that one thing is like another. But, what is being compared to what? There is indeed a third element in the representation: not only the simile (a representational folder), not only the real world object (a real folder), but also the thing it really is (a bundle of functionalities and a data structure). The simile becomes then a sort of cognitive mediator between a real world object and something going on inside the computer. As a consequence of all this, using interface similes implies forming a mental model of what is going on inside the computer that incorporates an understanding of all these three parts. And this does not only mean that interface metaphors indeed fail in simplifying the interaction, but also that they act as pointers to the wrong thing, i.e., to the internal operations of the computer.

Mental Models can be Adequate Interface Metaphors
"It is not enough simply to try to show the user how the system is functioning beneath its opaque surfaces; a useful representation must be cognitively transparent in the sense of facilitating the user's ability to grow a productive mental model of relevant aspects of the system. We must be careful to separate physical fidelity from cognitive fidelity, recognizing that an "accurate" rendition of the system's inner workings does not necessarily provide the best resource for constructing a clear mental picture of its central abstractions" [Brown 1986].

In other words, such mental models should not focus on what the computer is doing, but on what it is going on in the representation, that is on the context, the objects, the agents, and all the activities of the virtual world.

Consider the following example: a woman is trying to edit her recipe database. Having discovered that it is vile, she wants to remove the recipe for "Fish Bisque". She consults her user manual to find the command that invokes the file system editor. Then she must select the file to be deleted from the list of file names, then return to the command menu and select the "delete" command [Laurel 1986]. Why can't she simply delete "Fish Bisque"? Because the interface creates a situation in which the user can not do what she would like to be doing, but it insists on the assumption that what the user is doing is actually using a computer. This springs from the idea that the computer is a tool, a tool to carry out commands, precisely what programmers do. And that programming is therefore the model for human-computer interaction, while outcomes like database management are secondary consequences of that sort of interaction. But a computer is distinct from any representation it represents, and end user are not interested in developing a representation, what programmers actually do: all they want to do is to move around inside one, to operate in a mimetic context.

The intimate nature of the computer is such that it can act like a machine or like a language to be shaped and exploited. It is a medium insofar as it can simulate dynamically the details of any other medium. It is the first metamedium and, as such, it has degree of freedom for data representation and expression. The most striking consequence of all this is that it is no longer important to specify what is actually represented in the medium computer, but, on the contrary, to specify the co-ordinates of the actions undertaken by multiple agents, one of which is the computer itself. Objects, environments, and characters are all subsidiary to the designing of the process of interaction. Since interfaces enable and represent actions, an effective interface design must then begin with an analysis of what a person is trying to do (to have an adventure in a fantasy world or to remove a rotten recipe from a database), rather than with a metaphor or a notion of what the screen should display.

Mental Models as the Base for a Good Interface Design

When talking about interface design, we indirectly refer to two sides: the system side and the human side. We change the interface at the system side through proper design. And we change the interface at the human side through training and experience. Ideally, no psychological effort is required. But this is the case only either with simple situations or with experienced users. In all other cases, i.e., with complex tasks or with unexperienced users, the user has to engage in a planning process in order to switch from an intention to an action sequence. Here is the need for mental models.

The term mental model has so far been applied to a variety of representations which, though deeply related, present an intimate different nature, e.g., the system's model of the user (see [Wahlster & Kobsa 1989] for an overview of the field), or the designer's model of the system [Hollan 1990], or the model of the system, i.e., the system's image [Norman 1986]. In this presentation the term will only be used to refer to the knowledge inferred by the user on the system s/he is interacting with, with the intention to foster a discussion on the extent to which such mental models can support navigation in any hypermedia application.

The claim that mental models can enhance navigation in hypermedia systems is not new (see, e.g., [Nielsen 1987] for an overview of the field), but the reasons behind such a claim are, i.e., to base hypermedia design on adequate metaphors and to make man-machine communication effective. These models indeed provide predictive and explanatory power to understand the interaction. And they are as well highly affected by the nature of the interaction itself. The system has therefore to be designed in a way that, at first, follows a coherent and consistent conceptualization, i.e., the design model, and, in addition, allows the user to develop a mental model of the system at hand, i.e., the user model, which, in its turn, has to be consistent with the design model.
Hypermedia Navigation and Mental Models

Navigation as a search for information still constitutes the bottleneck of most hypermedia systems. Exclusively manual methods for creating links between hypermedia elements are indeed quite restrictive, and even more limiting than, e.g., the keywords used in many computer-based bibliographies. They present barriers to the exploitation of the hyperspace and they are cumbersome to introduce and to manage even in small systems [Kibby & Mayes 1989].

Previous studies [Elm & Woods 1985] [Oborne 1990] have demonstrated that getting lost is a consequence of the lack of a "clear conception of the relationships within the system" [Elm & Woods, 1985]. This statement seems to imply the assumption that an easy navigation depends upon the ability on the side of the user to abstract from the system display in order to build a conceptual representation of its architecture. The conclusion that such a representation, call it mental model, has to be prompted by the system itself simply sounds as an inevitable step further on. We have tested this truism by examining the influence of different types of cue on the user's navigation procedure within a hypermedia system. Next section will provide the details of the experimental setting.

The Experimental Setting

We have asked a group of 25 language practitioners, either university students or members of the department staff, to interact with ITEM. ITEM (Interactive Tutoring Encyclopedia based on Multimedia) is a hypermedia application in the field of special purpose language learning conceived as an educational complement to classroom teaching: it is used to learn Italian as applied to business and economical education. ITEM already exists as prototype. As such, it runs under MS-Windows, on PCs. ITEM presents three different kinds of cues for navigation: a hierarchical content list, typographical cues like hypertextual and hypermedia links between elements, and a structural overview of the whole system in the form of a block diagram, i.e., a map. The content list is nothing more than a simple index as the ones printed in books, where information is given relative to the subdivision of the system into chapters. In addition here it is possible to activate via mouse a description of the selected chapter as a further device to a guided navigation. The typographical cues range from the so-called "hotwords", i.e., words that, once selected, access new information regardless of its location within the hyperspace, to graphical icons with the same hyperfeature. The system map takes indeed the form of a block diagram, where the system structure is depicted in all its elements and in the relationships between them.

Users were asked to accomplish two subsequent tasks: first, they simply had to perform some arbitrary navigation, just to get familiar with the system. In a successive phase, they were expected to collect some data located anywhere within the hyperspace and to verbalize the strategy they had adopted in that respect. Following Young's suggestion [Young 1983], users' mental models were elicited by observing the users learning the application.

The Findings

As already mentioned above, we wanted to verify two hypotheses, namely to test whether there exists a correlation between the user's ability to navigate within a hypermedia system and his/her ability to build up a mental model of its structure, and, provided that the system itself has to prompt the development of such a mental model from the user, whether there are better cues than others in this respect and which ones they are [Calvi & Geerts 1995].

The first hypothesis has proven to be true: as long as a user has no mental model of the system, navigation is blind, and the user is practically lost. The users' ability to build such a model is a function of the number of times users interact with the system. In our experiment, all users reported to have gained familiarity with the system only after several sessions with it, an observation which testifies how intricate its structure is indeed, but that they were able to figure out general co-ordinates quite soon. They have reported that they could vaguely imagine the system architecture already after the first session, and that they were then using such sketched model as a basis to be incrementally improved towards a more definite representation. In this process most users have employed the content list as first attempt to get more information about the system, but, successively, they have shifted to the map neglecting the list quite persistently. To be more precise, 75% of our users have shown to
prefer the map over the content list. The reason for this is that the map is considered to be clearer than the content list in what it depicts: its structure seems to apply to the principle "what you see is what you get"; it is more exhaustive as long as it provides the user with all the structural elements of the system and the connections between them; and more useful in the way it is conceived: the user doesn't need provisional jumps in order to decide which further step to take, all s/he needs to know is depicted there. Despite all this, 85% of the users have declared to have used the content list as first approach to the system. This percentage has nevertheless completely reversed in all subsequent cases, with 85% of the users adopting the map, 10% still adopting the content list and only 5% employing the hypertextual elements. What has emerged from the experiment is the subordinate role assigned by users to the typographical elements as cues for navigation. They were mainly considered a further elaboration of the content list, and, because of this, neglected in favour of this latter one. Few users have claimed the content list and the map to be redundant; on the contrary, most of them consider these two kinds of cues complementary, with the provision of the map to be more complete than the index. This statement would explain the reason why the index is abandoned by 85% of the users after the first session with the system as a tool to orient navigation. This means that the reason why it is chosen in the first place is to be found in its nature which is more familiar to most users than the map: an index is present in all books, and for this reason the content list has been of help for users to gain familiarity with the system.

The second hypothesis has also been proven, with the conclusion that the development of mental models on the side of the users is mainly affected by the map of the system.

Conclusion

We have started our paper by formulating two related hypotheses, namely that navigation within hyperspace is affected by the development of mental models on behalf of the users, and that not all possible cues to navigation influence such a conceptual process in the same way and with the same strength.

We have tested such hypotheses by examining thinking aloud protocols provided by users interacting with a hypermedia application. The analysis of the results has shown that both hypotheses are proven.

References


Abstract: The paper describes an experience in collaborative teaching/learning using INTERNET and World Wide Web [Zeltzer 95]. A teaching/learning environment that provides tools for enhancing the communication process between all participants in the experience was built by adapting and enhancing existing tools currently available in the Web according to the specific needs of the project. A prototype of the environment is currently being used in the development of a distance education course related to human-machine interface issues both as a tool and as a study case.

The Problem

We are developing an effective mechanism for offering a distance education course using INTERNET and the World-Wide Web. In particular, a course on Human-Computer Interface Design was considered as a study case. For all operational purposes, the instructor was located at Buffalo, NY, USA, and the students were at Universidad de Concepción, Concepción, Chile.

We defined an effective mechanism as one able to provide the following services:

- Documents sharing: Suggested readings must be available for revision, discussion, and, eventually, modification by all participants.

- Message sharing: Messages must be shared by the participants with minimum effort. Emphasis must be in content, not in operational aspects.

- Idea sharing: Ideas must be shared, if it is possible when they arise, so that the participants can be engaged in active discussions about the ideas and their relation with other materials.

Methodology

Following the ideas proposed by Fainholc and Derrico [Fainholc & Derrico 94] we consider the following aspects during the development of environments and materials for open and distance education:

Epistemological Aspects

a) Structure of the domain knowledge.- It is defined by the course curriculum.

b) Methods and techniques involved in knowledge acquisition.- The student knowledge acquisition process is supported by the following activities: Bibliographic research, conceptual structure diagram construction, informed discussions, info repositories, critical evaluation of documents and software products, individual and collective prototype design and implementation.
c) Symbolic codes of media involved in the transmission of knowledge.- The accessibility to multimodal information and tools for real-time multimedia communication provides us an interesting environment for analysis and discussion about the way in which each media contributes to the communication process, both in isolation and in combination with other media.

Psychological Aspects

a) The level of the user.- In our case, undergraduate and graduate students.

b) The learning theory adopted.- A constructivistic, cognitivistic, interactivistic theory.

c) The comprehensibility of the material based on the cognitive and meta-cognitive abilities of the participants in the experience.- Besides the exposition to the huge amount of material available through WWW might be considered as a potential cause of cognitive overload, it provides the possibility of getting a broad view about particular issues. As participants in the course not necessarily review the same material, concepts and positions can be discussed from different points of views, according to the motivation of the students.

Sociological Aspects

a) The communicational model and relation styles that they support.- The communication model considered during our project consider the following actors: instructor, researchers, students. The following interaction styles are considered and supported by the model:

   - Instructor and students relate each other in two modalities: Tutor-tutored, and as peers.

   - Students relate each other as peers. Eventually, some student might adopt the role of leader and conduct the communicative process.

   - Researchers, instructor, and students relate each other indirectly via documents and, eventually, the might be in direct communication via E-mail, text, audio or video-conference.

b) The interactivity and the social production of culture.- We strongly believe that the key for learning is interaction. In our conception, the instructor, more than an information provider, becomes in a facilitator of interactions between students, and between information sources and students. Instead of presentation of canned definitions for concepts, activities are oriented to develop a social construction of meanings via negotiation of individual understanding of the concepts.

Semiotical Aspects

a) Creation of cultural meanings.- As it was mentioned above, concept meanings emerge from discussion, providing common grounds for further interactions between the participants in the experience.

b) Creativity.- Through analysis, comparison, and contrasting positions new ideas arise providing new solutions to problems. The accessibility to the newest sources of information and tools for searching, retrieval, distribution, and access provides continuous challenges to the participants as they realize current limitations of the state of the art in their area of interest.

Didactical Aspects

The mixture between passive and active positions in learning.- By mixing reading, discussions, testing, and prototype analysis and design we cover the spectrum of positions in learning, enabling the students to exploit their personal abilities and preferences, as well as to explore alternate ways of facing the learning process.

Operational Aspects
From an operational point of view, participants relate each other according to the following guidelines:

- A set of materials is initially available to the students (course description, course schedule, suggested readings, course notes, project descriptions, etc.)

- Each participant can propose enhancements to existing documents (in particular, course notes, by attaching hyper-links to those concepts he/she considers interesting).

- Answers to exercises, homeworks, and projects from each student are shared with all participants for comments and discussion.

- Periodically, a virtual meeting occurs. These meetings are oriented to discuss issues about course notes, suggested readings, projects, etc. During these meetings all participants have equal access to all information and they are supposed to engage in active discussion.

- Discussions are recorded, being accessible to each participant at the end of each meeting. This provides both, a mechanism for reviewing the discussion process and the concepts involved in the dicussion, and the possibility, for those students that did not attend to a particular virtual meeting, of submit followup comments contributing also to the discussion of a particular topic.

- At any time, a participant can send to the others participants questions, comments, etc. about some content/course-related issue. Messages can be shared with the other participants, being available in a central repository for further revision.

Experiences

Experience 1 - 1994

During the second semester of 1994, the Human-Computer Interfaces course was offered. Students were introduced in the use of WWW for message and document sharing [Hong et al. 94], [Rebelsky 94], and UNIX tools (talk, ytalk) oriented to support interactive dialogue. Virtual meeting interactions were recorded for further analysis. They were available as HTML documents to all participants.

The mixture of different tools in the development of virtual meetings and network stability and response times were the two main problems detected during this first experience. As expected, students showed a strong preference for interactive on-line discussion in contrast with off-line discussion via E-mail.

Experience 2 - 1995

Based on the results of the [Experience 1], and trying to enhance the development of an inter-subject consciousness about the topics of the course, during 1995 we developed a WWW-based integrated environment for collaborative work (HCID) oriented to promote cognitive processes such as: analysis and discrimination, generalization processes, reflection, discussion, problem solving, conceptual organization, and heuristic research.

As part of this effort, we reviewed different interactive tools for audio and video-conferencing [Ibrahim & Franklin 95], [Dwyer et al. 95], and we evaluated them from the point of view of usability. The conclusions of this study were considered in the development of a prototype version of HCID that enables the participants to share ideas interactively during virtual meetings and provides automatic actualization of the shared information space each time that a participant contributes to the conversation. This prototype is currently being tested by our students.

The environment
The design of the environment was based on previous studies about the tools students use during their learning process [Campos et al., 94], [Campos & Claveria, 95]. The structure of the system is shown in [Fig. 1]. The modules considered are:

- Course information: Syllabus, rules, evaluation, participants.
- Reading/working materials: Handouts and on-line interactive tutorials.
- Homeworks and projects: Project proposals and development history, homeworks and results. This module is linked to the homework and project pages in each student account.
- Virtual Library: Search Tools and pointers to topic-related interesting places.
- Virtual classroom: E-Mail and tools for multimedia (WebChat-m), audio (InternetPhone), and videoconference (Cu-SeeMe).

![Figure 1: The structure of HCID.](image)

**Results**

We are developing a framework for distance education using WWW that provides an environment for delivering instructional material and mechanisms to achieve an effective communication with the students. This framework is currently being used to offer a course about human-computer interfaces in which usability testing and further development of the environment are, by themselves, some of the most important activities. The active participation of students in the experiences described above, has been a critical factor for the success of the project.

Having exposed the students to different tools and setups, it is interesting to note the importance of student's expectations in relation to services and response times of the different interaction-support tools of the environment. Students preference for completely on-line or completely off-line tools, instead of almost real-time tools was clear.

According to the experiences, the environment usually acts as a trigger for motivation, as the student role changes from passive learner to a partner in the goal of constructing meaning and understanding through interaction.

**Conclusions**

Our proposal can be related with a cognitivistic, constructivistic and mediatic conception of the teaching/learning process based on the idea that the knowledge building process is only possible through
interaction between the subjects and the objects of knowledge that can be mediatized either presententially or at distance.

The relativization of perspectives, the access to different styles of information coding according to the media used to convey the information, the challenge of facing different points of view and contradictory opinions about some issue, are some aspects emphasized in our project.

It is not a simple task to help subjects to learn by themselves. Instructional material must fit with subjects' schemes and their cognitive tools. But, simultaneously, current schemes and cognitive tools must be improved. The development of teaching/learning environments as the one described in this paper is a way of facing both goals simultaneously.

References


Acknowledgements

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The Experiential Learning Cycle as a Framework for Integrating Multimedia Case Studies and Task Workbenches

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Abstract: Two prototype systems are used to illustrate issues raised by the integration of the experiential learning cycle model with multimedia interactions, case studies and active learning through task workbenches with context sensitive guidance. The FLUID system for learning about design of interactive software systems supplements goal-based scenarios with elements of the experiential learning cycle model. The Action C++ system, for learning about the C++ computer programming language, demonstrates how an engaging video character can be used to support explicit transitions through the stages of the learning cycle while maintaining equal focus on doing and on understanding.

Doing + understanding: experiential learning cycles

Active learning requires that students are actively engaged in both acquiring and applying knowledge. If learning activities focus solely on the acquisition of conceptual knowledge, the knowledge may be inert - accessible only by direct probe and not readily applied to problem solving. If learning activities focus solely on carrying out tasks in hopes that performance will lead to understanding, the knowledge may be overly simplistic and not capable of generalization to performance of new tasks.

The necessity to plan for learning activities linking task performance and conceptual understanding was described by David Kolb as the fostering of Experiential Learning Cycles [Kolb 1984]. Based upon the work of Kurt Lewin (group dynamics), Piaget, and Bruner, the Experiential Learning Cycle represents learning as a process of translating experiences into concepts, in a cycle of four stages: Concrete Experience, Reflective Observation, Abstract Conceptualization and Active Experimentation. Kolb hypothesized that each learner is pre-disposed to particular stages of the learning cycle and may initially focus on those kinds of learning activities. Using the Experiential Learning Cycle as a framework for interactive learning systems helps in designing appropriate instructional activities to support all learning styles and each step of the process. [Sviniki and Dixon 1985]

Activities designed to support the first stage of the experiential learning cycle, Concrete Experience, focus on "doing". They draw on the previous experience of the learner, as well as new task-oriented experiences provided by the learning environment. Common experiences, examples from everyday life, or new task experiences may be introduced during this stage. The experiences must engage the learner, evoking feelings, thought and action in the performance of the task.

Activities for Reflective Observation support 'understanding the doing'. The learner is assisted to examine the experience, focusing on the synthesis of meanings, associations and connections. Techniques for eliciting and organizing reflection include rhetorical questions - "How does this fit together?" and "How does this fit with what I already know?" - recording and analysing observations, and comparison with other experiences.

Activities for Abstract Conceptualization shift the focus to 'understanding', in which the learner builds a theory or model. This model is the essence of the concrete experience, the general principle, explored and uncovered through the reflection process. If the learner has had access to appropriate experiences, and reflection has been encouraged, the general principle will be easily uncovered..

Finally, activities supporting Active Experimentation focus on 'doing the understanding', exploring the abstract knowledge through application to real situations. Through simulations, experiments and problem sets, active experimentation solidifies the model in the mind of the student. It links theory and practice, and opens the way
to new experiences that begin the learning cycle again. Active experimentation gives the student the chance to apply, test and refine the new conceptual models.

Computer aided instruction systems following the Experiential Learning Cycle have already shown success. For example, Hsi and Agogino designed a system for presenting engineering case studies which took into account the Experiential Learning Cycle and found that, "The impact of multimedia case studies for teaching engineering design has been positive for generating excitement in engineering, conveying industry practice, and demonstrating design process." [Hsi and Agogino 1994]

The system used by Hsi and Agogino relies on supporting print materials and interactions with instructional staff to provide an active learning experience. We report here on efforts to incorporate the progressive stages of the experiential learning cycles more explicitly into interactive learning systems. The two prototypes we describe integrate multimedia case studies with a task workbench where the active learning takes place, using the experiential learning cycles as an organizing framework.

Supplementing Goal-Based Scenarios with Experiential Learning Cycles: the FLUID prototype

The FLUID system is a prototype multimedia environment for learning about the design of interactive software systems. We have used FLUID - the Framework for Learning User Interface Design - to support learning of user interface design techniques [van Aalst et al 1995]. FLUID combines the overall structure of goal-based scenarios [Schank 1994] with additional components intended to support an experiential learning cycle.

Figure 1(a) [Fig. 1] shows the central Agenda screen in FLUID, which has the standard goal-based scenario structure:
- task and role presentation
- task performance within the simulated role
- reporting on the task, the performance and the role.

In the example illustrated here, the learner is assigned a role on a user interface design team for a case study based on work at Apple Computer [Houde 1992]. The use of scenario roles is particularly useful in a design case study where feedback on design quality must come from usage. In FLUID, the learner's designs are tested by simulating feedback from usage, employing data from the Apple case study.

A sample screen from the role introduction is shown in Figure 1(b) [Fig. 1]. The learner carries out this role by using a particular design technique (Design Space Analysis), [MacLean et al 1991] on a task workbench as shown in Figure 1(c) [Fig. 1]. Throughout the learning activities, video guides provide support and advice.

Figure 1: Fluid Agenda

The "learning by doing" model used in goal-based scenarios tends to treat concept acquisition as a peripheral activity. We wanted to place more emphasis on developing understanding as a key element in the learning process, so we added components to FLUID to support reflection, conceptualization and experimentation leading back to performing the assigned task experience. The resource set is always accessible through the navigational buttons in the lower left corner of the screen.

When the learner has completed the initial role and task presentation, the system suggests engagement with the Tutorial resource. This begins with a reflection on what is difficult about the task to be carried out, as illustrated in Figure 2(a) [Fig. 2]. The concepts of Design Space Analysis are then presented as a solution, Figure 2(b) [Fig. 2], and further developed through examples. Learners are encouraged to work through a Case Study, Figure 2(c) [Fig. 2], to experiment with the concepts before entering the task workbench for the concrete experience of performing the task. The final goal-based scenario stage of reporting the results is intended to become a reflective observation on the experience, leading on to new learning cycles.

While users of FLUID were able to acquire and later apply the concepts of the technique being taught, we learned a number of lessons about how we could improve the synthesis of goal-based scenarios and experiential learning cycles. The concepts of the experiential learning cycle provided a useful framework for our interpretation of learner difficulties. First, the initial role and task presentation did not give learners sufficient
concrete experience with the task. The subsequent reflection was therefore premature, and seemed to some to interrupt the task process rather than support it. In the next FLUID prototype, learners will engage with the task requirements more extensively before we prompt them to engage in reflection on their need for a design technique as an aid.

Second, the transition from conceptualization to experimentation was obscured in the tutorial by an explanation of the operations for the task workbench. The workbench instructions should have been placed as a preface to the Workbench element within the main Agenda. This reflected an overall strategy of preserving the goal-based scenario as an intact structure supplemented by the experiential learning elements, rather than truly integrating the two approaches.

Lastly, use of the Case Study was too passive. This might be less noticeable when the case study is the central focus of activity, as in [Hsi and Agogino 1994]. But when the focus has been placed on a role scenario, the case study needs to be very engaging and the relationship back to the conceptualization and forward to completing the concrete task must be clear.

Overall, we found we had focused too much on the learning styles hypothesized in Kolb's work and needed to shift to a more explicit focus on the cycle process. The prototype system described next, Action C++, instantiates the experiential learning cycle more directly.

Learning from case studies of object-oriented programming:

Action C++

Action C++ is a prototype interactive multimedia environment for learning the C++ programming language, designed using Kolb's model of experiential learning cycles as a framework. Current multimedia tutorials for programming languages present large amounts of information, but do not integrate it into concrete task experiences. A typical C++ tutorial lesson begins with an explanation of the topic to be considered, or an example of a program or process. The tutorial outlines the theory involved, and relates it to the example. Finally a quiz, or practice session is given to the learner. Examples of this approach include: Experience C++ [IBM, 1993] and the Waite Group's Master C++ [Woolard, Lafore and Henderson, 1984].

Action C++ presents learners with a concrete case study problem which they explore on a restricted task workbench, then leads them through reflection and conceptualization stages back to a workbench where they can complete the task. Action C++ uses video guides and other engaging multimedia elements to integrate the various elements of the cycles and to proactively lead learners through the stages. The Action C++ Guru, a video actor, is used to help create an action environment. Interactions are chosen for each sub-topic to support the stages of the experiential learning cycle. For example, the student and the Guru co-operate to place the parts of a program in place (concrete experience). The Guru then suggests some areas that deserve further reflection. The program makes available the reference material on the C++ language, and illustrates the relationships between concept and experience with simple animations and interactions. Finally, the Action C++ tutorial gives the student a workbench (a working compiler) to experiment with the concepts and material.

A typical Action C++ topic unit

An Action C++ topic unit begins with an example, introduced by the Guru. An early role for the Guru appears to be essential in order to encourage learners to see the task as composed of both doing and understanding. Constructed incrementally by both the student and the Guru video actor as illustrated in Figure 3(a) [Fig. 3], the example is the first concrete experience. The Guru actor responds to the objects dropped into place. Objects may be moved, rejected, or commented on by the Guru. This makes a simple interaction a shared experience, without requiring a sophisticated user model to analyse actions or program segments. The emphasis is on reading and structuring program elements in order to keep the learner's attention focused on the approach to the construction of the program. The learner begins to grasp the relationship between parts of the program and object oriented design by doing, without the completely open-ended work permitted by a full workbench.
The example is then shown, as it appears in a programming language compiler Figure 3(b) [Fig. 3] and the student is asked specific questions about it to promote reflection. These questions may outline the rationale behind certain choices, or address common questions and misconceptions.

The student is introduced to an analogy, the blueprint, as shown in Figure 3(c) [Fig. 3] and asked to list some similarities and differences. The example of the blueprint expands, and is removed as the student is presented with the theory of the topic unit. This interaction with the topics keeps the conceptualization stage engaging, and illustrates the parallels between the theory and the original concrete task.

Finally, the student is given a workbench on which to complete the task, as shown in Figure 3(d) [Fig. 3]. The workbench is completely functional programming language compiler, but has some of the features pre-set and others blocked off. This facilitates experimentation with the example, but prevents the student from accidentally changing unrelated parts of the environment. The Guru introduces the material, outlining the areas that might provide for the most interesting experiments, but then leaves the actual building of a program solution up to the learner.

Conclusions and Research issues

Where the FLUID system emphasized a task process using goal-based scenarios, Action C++ emphasizes task concepts without a role simulation. Both use intrinsic feedback on task performance, FLUID through simulated user reactions and Action C++ by running the program on the compiler workbench. Both use video guides to support learning, but Action C++ employs the Guru guide as an integrator so that the focus on doing the task does not overshadow the goal of conceptual understanding. Action C++ employs more probing of learner actions early in the cycle to aid the transition to reflective activity, but adopts a passive stance later when the focus returns to active experimentation.

Our experience confirms that of Schank [1994], that the use of engaging characterizations can increase users' interest and allow us to more effectively direct them towards complete learning cycles while maintaining a strong sense of self-direction by learners. A useful next step would be to introduce additional Guru-type interactions to support acquisition of meta-cognitive skills, so that learners could more consciously choose activities providing a complete learning cycle. In FLUID, the role of the Manager video character was intended to provide guidance on such meta-task issues, but was limited by the need to stay within the scenario role and by our decision to restrict all advice on the workbench to a single context sensitive response from each video guide. This makes sense for the guides providing performance guidance but is not a helpful for meta guidance.

Similarly, each of our prototypes uses a simplified task process and workbench, as a "training wheels" interface [Cattrambone and Carroll 1987]. This makes the task process more explicit and thus allows us to provide more effective task guidance. There should also be reflection by the learners on how the task will change when these restrictions are removed. In Action C++, this can perhaps be done in an engaging manner by a final conversation with the Guru. In FLUID this reflection occurs now in the tutorial immediately following the conceptualization stage; it would be much more effective after the concrete experience of completing the design. Generally, we believe that the concluding stage of a goal-based scenario has to support the initiation of reflective observation on the task, as the start of a new higher-level learning cycle.

Finally, the use of case studies to complement role simulations and problem exercises needs to be explored further. Our development of Action C++ was influenced by the literature on case studies as an aid to learning programming languages e.g. [Linn and Clancy, 1992], although we have not yet exploited the full potential of the case study approach - for example, we could use a case study in which the requirements for a program change to illustrate how proper use of C++ constructs can support program evolution. FLUID began with two case studies from Apple Computer, but we did not integrate the actual case details and history with the somewhat sanitized version presented in the goal-based scenarios. We are investigating how case study materials can be re-purposed so that learners can engage with them at several levels of depth, including self-directed study, guidance by a case "wizard", and full role simulations.

References


A Formal Approach to the EMI Model and Case Study

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Abstract: A model for the formalization of the skill acquisition and learning model as described in the companion paper [Boumedine96] is presented. A measurement and controlled observation scheme based on structured observation of the plans autonomously designed by the student as he/she solves a tangible but non-monotonic real-life problem in a computational fashion is defined in terms of a hypermedia tutoring system architecture. The purpose of the formal scheme is to show how multidisciplinary research may allow us to merge [traditionally] incompatible fields of study such as Psychology, Cognition and Artificial Intelligence, by identifying particular behavior patterns which may be measured qualitatively and quantitatively and thus provide a solid framework for feedback onto the software engineering of a computerized educational tool for Virtual University Model [Espinosa95b] and [Espinosa96b].

Keywords: Cognition, Education, Hypermedia, Machine Intelligence, Singularity, Taxonomy, Measurement.

1. Introduction

One of the most frequent problems in the school realm is trying to create an environment in the classroom such that it closely resembles real life. That is to try to educate more autonomous students that learn to learn, by following a top-down approach that simulates the real-life dilemma of on-the-job training and demand for high-quality results given a set of incomplete and subjective initial requirements [Peters94]. At the same time, we teachers are trying to learn more about the students as human beings. Given the epistemological strategy that humans will not be treated as machines, and thus will trace their own educational plans based on their own needs, as depicted in [Boumedine96], we now proceed to define how we are able to make a statistical recollection of the experiences and skills gathered by our students as they traverse an educational universe designed to allow multiple solution paths. Our tool is a formal specification, aimed at the characterization of the properties relevant to the EMI Model, thus making it a computable approach to educational measurement.

2. The fusion of Cognition, Educational Technology and Artificial Intelligence

The EMI Model [Boumedine96] is now characterized in terms of a computable scheme. The formalization is based on the three cognitive variables depicted in that article: Field Dependence/Independence, Reinforcement Units and Taxonomic Level of Learning, plus their introduction to a hierarchically-defined hypermedia software engineering effort, which forces us to treat educational entities as members of a state-space with the topology of an undirected, densely connected graph datastructure, with the structural definition shown in (A).

We expand this purely computational structure, adding the human-educational variables so that the Educational Media (EM) results, as shown in (B). An Educational Prerequisite (EP) is a piece of knowledge the student must be able to handle somehow during the course of the semester, given that the previous course. It is understood that EP’s are formed from the basic educational objectives traditionally defined for college courses. Given our new approach to education [Espinosa95b] [Espinosa96b], also discussed in [Boumedine96], we recognize the value of Skills and Experiences. We reflect these in (C) and (D).
A **Personal Profile** (PF) is a Psychological unit of measurement which enables us to qualify the personality traits of the student. The units of measurement are Field Dependence or Independence. They are intended to provide a reference criteria by which to identify students once the structured observations of their educational behavior are completed. People are not entirely field dependent of independent. Therefore, we define the student profile in (E).

We understand by **Educational State** (ES) a temporal state of the student’s knowledge corpus, as defined by the Taxonomy of Benjamin Bloom in [Bloom90]. ES’s can actually be any of S₀, SI or S_f in (B). We now provide a starting point for the characterization of this corpus in the analysis of the EP’s.

In the case of the Initial State, S₀, the Educational Prerequisite (EP) will directly affect the knowledge corpus as the first Educational State (ES) comes into existence, as shown in (G).

Each topic of the lab session, week-long period, or semester-long course has a set of taxonomical units, each with a specified weight. The weights increase as the ES is encountered deeper in the graph. For example, the graph in Figure 1 shows a sample set of educational units. ES₁, ES₂ and ES₃ are prerequisites for all other ES’s, but we are unable to predict which internal path and corresponding path length will the student choose to follow in order to reach ES₂₆, ES₂₇ or ES₂₈, which are defined as the possible final states. The
join operator (Π) onto (TD × TU × TW) is meant to provide us with a statistical view of the student’s visit to the ES. Upon
the termination of an ES, the new cognitive elements are mapped into the knowledge corpus of the student. The knowledge
the student possesses is thus modified as the he/she traverses the current ES. It is important to note that, as one ES is finished,
the student may go back to it as he/she requires. This is closely tied to the concept of the autonomous student building his/her
own educational plan, as stated from [Boumedine96] and [Espinosa96b]. This cyclic path traversal is allowed by the
undirected nature of the graph (A). Since past ES’s must become PQ’s of future ES’s, a new mapping is required from the
taxonomical levels achieved in the last ES to one or more EP. We therefore define the criteria which allows us to qualitatively
measure the student’s recently met goals.

Let:

<table>
<thead>
<tr>
<th>Data</th>
<th>Experience</th>
<th>Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro(Data) = Encounter with Information (introduction) or</td>
<td>Exp(Data) = Applic(Intro(Data))</td>
<td>Skill(Data) = Analysis(Exp(Data)) or</td>
</tr>
<tr>
<td>Comp (Data) = Fixation of Information (ie. Comprehension)</td>
<td>= Synthesis(Exp(Data))</td>
<td></td>
</tr>
</tbody>
</table>

The taxonomic levels by Bloom [Boumedine96] [Bloom90] are again used, this time to allow the statistical (quantitative)
measurement of the student’s passage through the ES. Only if the student has proved his/her understanding of an Introduction
and/or a Comprehension node, will the system register the Intro(Data) or the Comp(Data) operation. This will mean that the
TW’s are weighted with respect to the internal path length of the student’s voyage. Our conclusions will derive from the
statistical revision of these factors along with the personality profile of each of them (see below). There is still a degree of
influence of the traditional educational model on these experiments. The Topic Description (TD) is the result of the basic
structure of the course. The Taxonomical Weight (TW) is a importance measurement given the context of the course. If the
student comes to master a given topic (TD), he/she will have completed a quantifiable measure of effort (TW), which is
qualifiable by Bloom’s Taxonomy (TU). We currently work under the condition that as we traverse Bloom’s Taxonomy from
Introduction to Evaluation, the level of difficulty grows, along with the TW. Under this schema the following is possible:

TD1 = Mathematical Concept of the Stack ADT (ie. explanation, definition and examples - both mathematical and in text form)
TU1 = Introduction
TW1 = 0.2

TD2 = Push Operation on the Stack ADT, implemented in C++ (ie. sequential exploration of the code and algorithm)
TU2 = Application
TW2 = 0.5

TD3 = Arithmetic Expression Evaluation Scheme using Stacks (ie. situation explained, context of action, relevance and solution
strategy)
TU3 = Synthesis
TW3 = 0.9

The last part of the tuple definition for Educational State, namely { → Ki } in:

\[
ES = \{ \Pi (TD_i \times TU_i \times TW_i) \rightarrow K_i \} \quad (J)
\]

Allows us to link the educational material contained in an educational hypermedia system, as follows. The student contains a
modifiable knowledge corpus. Since we are interested in both recording the voyage, its operational parameters, and the level
of knowledge acquisition efficiency, we will verify the modification of the knowledge corpus by applying Reinforcement
Units [Boumedine96] to the human student. We will then correlate the results with the formalized ES’s as we obtain data from
the computer system. Using this controlled observation method, we intend to reinforce our knowledge about the singular
educational requirements a Virtual University may have. We present a detailed example of this concept in the next section.

It is stated in [Boumedine96] that the student is free to traverse the graph as he or she considers necessary. Since it is uncertain
the internal path the student will follow, we treat an EM as a recursive concept, given that EM’s may be contained in other
EM’s, as follows:

\[
Em_i = (PQ, PF, S_i, (PQ, PF, S_1, (PQ, PF, S_2, S_i, SI, ET), SI, ET), SI, ET) \quad (K)
\]

where:

\[
Em_2 = (PQ, PF, S_2, S_1, SI, ET)
\]
These concepts prove that we may have any combination of Educational Media units. Each of them contains a series of measurable parameters we can extract once the computational structure is implemented [Espinosa96a]. The final touch to the formalization is, however, the way in which we expect the hypermedia to link itself to the EMI Model via the formalized parameters hereby explained.

We now proceed to complete the definition of the formalized EMI Model by defining Educational Transactions (ET’s). An ET is a critical educational unit that turns the undirected graph into a truly educational hypermedia structure. According to the EMI Model, the internal state of the student changes as he/she goes through a process. Such process states must provide the [educational] material for the student to encounter, survey, comprehend, evaluate, and analyze at will. The knowledge corpus, along with the corresponding PQ’s, EP’s, PF’s and their related formal units will go into action upon entrance to a ES. We emphasize that the TD’s, TU’s and TW’s are all made out of any hypermedia gadgets a current tutoring system is capable of.

We then conclude that an Educational Transaction operates as follows.

Let an ET be defined as:

\[ ET = (S_0, PQ, PF, S_{in}, S_f) \rightarrow (PQ', T) \]  

Within an EM, an ET contemplates the student’s profile (PF) and how it deals with the actions he/she executes upon the presentation of the course material. That is, the ET contains the course material. An ET may be implemented as a hypermedia screen with a degree of Educational Autodetection [Espinosa96a]. Since \( S_0, S_{in} \) and \( S_f \in ES \), then they convey information regarding the taxonomical category the hypermedia state (ie. a screen) will depict. Consider the following:

\[ ET = (S_0, PQ, PF, S_{in}, S_f) \rightarrow (PQ', T) \]  

where:

\[ S_0 \in ES = \{ \prod (TD_0 \times TU_0 \times TW_0) \rightarrow K_0 \} \]
\[ TD_0 = \text{Mathematical Concept of the Stack ADT (mathematical and text)} \]
\[ TU_0 = \text{Introduction} \]
\[ TW_0 = 0.2 \]

It is understood that the student, upon passing through the first state in the ET, will be required to understand the concept of a Stack ADT. If so, a taxonomical Introduction will be registered, with a weight of 0.2. Given (L) this TU and TW will, in turn, become the prerequisite (PQ’) for the next ET. A time \( T \) (in (L)) will have elapsed. In this article, time is implicit. Further [related] work will be published in a later paper. As the session proceeds, the student will traverse a series of intermediate (Sin) states, such that:

\[ S_1 \in ES = \{ \prod (TD_1 \times TU_1 \times TW_1) \rightarrow K_1 \} \]
\[ TD_1 = \text{Mathematical Concept of the Stack ADT (mathematical and text)} \]
\[ TU_1 = \text{Introduction} \]
\[ TW_1 = 0.2 \]

\[ S_2 \in ES = \{ \prod (TD_2 \times TU_2 \times TW_2) \rightarrow K_2 \} \]
\[ TD = \text{Push Operation on the Stack ADT, implemented in C++ (ie. sequential exploration of the code and algorithm)} \]
\[ TU = \text{Application} \]
\[ TW = 0.5 \]

\[ S_3 \in ES = \{ \prod (TD_3 \times TU_3 \times TW_3) \rightarrow K_3 \} \]
\[ TD = \text{Arithmetic Expression Evaluation Scheme using Stacks (ie. situation explained, context of action, relevance and solution strategy)} \]
\[ TU = \text{Synthesis} \]
\[ TW = 0.9 \]

We now have a complete set of measurable intermediate states. The same procedure applies to the final state, with the [mostly] possible increase of TW as the final goal of the EM is reached.
Upon completion of the EM, we may query a datastructure that looks like the one shown in (M). The next step is to complete an Analysis and Introspection of the data built during the Data Collection phase. The resulting datastructure is [recursively] traversable. Along the way, we are able to statistically collect information regarding the type of student (PF), the screen he/she chose to review (EP, ES), the number of times this process was repeated (depth of recursion) and the timeline of the session. Using these parameters, we may examine the patterns of behavior over a semester-long case study. In accordance with [Boumedine96], each student thus plotted his/her own educational plan. Counseling may now acquire another dimension since the conduct is revealed by an [eventually Intelligent] Tutoring System. We finally emphasize that an Educational Transaction (ET) is the programmable unit inside a hypermedia system, contains all the class contents (in its contained Educational States), and is depicted in (N).

The use of time constraints in (P) is important since the singularity of our study permits a student to traverse the EM at his/her own pace. It is therefore equally valid to finish the assignment in 3 hours or to finish it in 1 hour. It is the content, and the nature of the Graph Datastructure which will enable us to make a more flexible evaluation of a person’s work (see conclusions and lase section of [Boumedine96]).

3. Case Study

The experimental model is being validated using the fully implemented EMI Model, where Data Definition concerns the modeling of the specific course structure according to the EM tuple. Data Collection concerns the actual execution of the hypermedia software built using the EMI Model and formalization [Espinosa96a] [Espinosa95a] [Espinosa94]. The system performs Data Collection, that is, builds individual (ie. personalized) datastructures as shown in (K) and (L). Each one of them contains the specific educational context of one student. The objective of our study is to make qualitative and quantitative analysis of the Datastructures group. The Analysis process in [Boumedine96] implies the extraction of the per-station datastructure, their storage, and filtering. Once we have a set of information, we undergo a process of interpretation so we may reach further conclusions. The last process, Introspection, refers to this.

We thus require an automated media which will allow us to keep track of all the activity being executed by the students. From the Psychological standpoint, the case study is being conducted in a way that Data Collection is being performed from day one of the semester. Data Collection is being conducted once a week during the lab sessions, as the development of the software allows it. Once the JAVA software is ready and operational, we will have a remote way of collecting data. This will, in turn, accelerate our Data Analysis and Introspection phases, allowing us to have a faster version update cycle, based on real needs from real students.

From the Educational standpoint, much work remains to be done in the field of cultural adaption to the virtual schemes as they begin to emerge. We are in the process of stabilizing the Virtual University concept [Espinosa95b] [Espinosa96b], and making it public to our academic community and student body. Logistical and strategic changes will take place as the first

| Em₀ = (PQ, PF, S₀, (PQ, PF, S₁, (PQ, PF, S₂, (PQ, PF, S₃, SI, ET), SI, ET), SI, ET), SI, ET), SI, ET) | (O) |
| ET₀(S₀, PQ, PF, S₀, S₁) → (PQ', T₀) | (P) |
| ET₁(S₁, PQ, PF, S₁, S₂) → (PQ'', T₁) |
| ... |
| ETₖ(Sₖ₋₁, PQ, PF, Sₖ₋₁, Sₖ) → (PQ⁽ᵏ⁾, Tₖ) |
graduates begin their professional lives, and translate their new growth pattern (ie. knowledge corpus) into real industrial actions. We will do intense marketing efforts during 1996 in order to make these studies and future experiences subject of intense debate. From the Artificial Intelligence standpoint, an Intelligent Tutor is still years away, as the professor is still not replaceable. The question is: will he/she be replaceable? Our case study has shown a great concern for this ethical issue. Another research line emerges as Intelligent Multiagent Systems [Maes94] [Minksy94] prove themselves as valuable tools for this purpose. From the Institutional standpoint, we will make recommendations for the evolution of our organizational procedures as the study reveals factors to consider. All of us must be ready for change.

4. Conclusions and Further Work
The motivational capabilities of the model and underlying software have yet to be proved. They will be sound once the students begin demanding the new scheme, as opposed to the traditional one. The validation of the structural mathematics and computational device demonstrated in this article will show us other pitfalls and important considerations we may have omitted here. Like any other mathematical model, EMI will evolve. This evolution is especially interesting given its multidisciplinary nature.

The evaluation issue has still to be solved. A new focus on grading criteria is becoming crucial as the new technology comes into place. The students’ questions with this respect require prompt answers. Technological innovation and validation is also a must. As we explore new grounds in the hypermedia and distributed computing areas [Espinosa96a], we will adapt our current [software and hardware] resources to comply with the virtual worlds now open to us. It is our commitment to emphasize the educational side of the virtual worlds, in innovative and imaginative ways. The merger of the Educational, Psychological and Computational ingredients is in its infancy. The interesting blend of researchers involved in this project teaches us everyday lessons in teamwork, group modeling, and distance transfer of information, as well as retraining of ourselves as academics. A complete research programme derives from these efforts. The modeling of human traits such as emotions and learning styles is a major research topic. As we deepen our knowledge of softbots [Maes94] and knowbots [Minksy94], we obtain invaluable information from the interdisciplinary effort taking place. Our future work includes the termination and refinement of the EMI Model, as well as of its formalization procedure, the issue of temporal relations between Educational Media units and their components plus their characterizations, and an implementation strategy. We will port the technology (Educational, Psychological and Computational) to other courses, in other fields of human activity. New prototypes for the Virtual University will be born then.

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Multiplatform Implementations of the EMI Model using the JAVA Technology

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Abstract : This paper presents work in progress at ITESM. A practical approach to the implementation of the skill acquisition and learning measurement model described in the companion papers [Boumedine96] [Espinosa96a] is presented. A series of multiplatform programming case studies that show how multidisciplinary research may allow us to merge [traditionally] incompatible fields of study such as Psychology, Cognition and Artificial Intelligence, by identifying particular behavior patterns which may be measured qualitatively and quantitatively are described. The software models are being tested in three computer platforms [Espinosa95a] [Espinosa94], all of which are portable to multiple scenarios using the World Wide Web, and therefore placeable in countless situations so that the Virtual University Model applies as described in [Espinosa95b] and [Espinosa96b]. The use of such a technology is fully justified.

Keywords: Remote Education, Distributed Education, Hypermedia, Taxonomy, Media in Education.

1. Introduction
One of the most frequent problems in the school realm is trying to create an environment in the classroom such that it closely resembles real life. That is to try to educate more autonomous students that learn to learn, by following a top-down approach that departs from an initial situation and goes down in technical complexity, until a computational concept, such as an algorithm, may be used for direct problem-solving. Computer programming has proved a difficult subject to teach, as described in [Boumedine96]. The pedagogical issues surrounding the academics of computer programming have been addressed by the EMI Model, both as a model, [Boumedine96], and formally [Espinosa96a]. The complexity of achieving qualifiable and quantifiable measurements have also been detected, especially when the target audience will be a virtual one [Espinosa95b] [Espinosa96b]. As we go through our case study as defined in [Espinosa96a], we acquire the need for computer-intensive labor aimed at the generation of a complex datastructure and initial measurement parameters per student station (whether local or remote), plus the eventual statistical computations necessary to perform the Analysis and Introspection phases of the case study as defined in [Boumedine96] and [Espinosa96a]. That is, the EMI Model demands a high quality laboratory, plus a computer center and remote connection infrastructure from ITESM. In order to satisfy these new software and hardware requirements, we turn out attention to a technology aimed at Distributed Computing on the Internet, one developed by SUN Microsystems, called the JAVA Technology [VanHoff95] [Banks95] [CBS95] [Karpinski95] [Oconnel95].

2. Multimedia, Hypermedia and the Virtual University
The development of multimedia software has been mainly based in the desktop platforms (e.g. Macintosh and PC.) Although Sillicon Graphics has entered as the state of the art competitor, authoring tools, audio, video and image-processing software are in the desktop marketing. Trying to develop multimedia applications in UNIX platforms is not only difficult because there are not many authoring tools, but it is also expensive comparing the value of the few software available to the one for desktop computers.

One of the main reasons people continue searching for UNIX-based multimedia development is the client/server model that allows distributed processing. Distributed processing systems have code and data resources scattered across several computers connected through data communication networks [Colouris88]. This kind of architecture allows individual computers connected through a network to share programs and data, even between remote geographical locations. Distributed systems have the benefit of improving the performance, reliability and availability of programs and data.
In the case of the Virtual University (VU) project at ITESM [Espinosa95b] [Espinosa96b], those three characteristics are of great importance. The student needs to be able to receiving the virtual class at the laboratories, library, home or any place where he can have access to a computer or workstation. The quality of what he sees and hears should be the same without depending on the computer platform that he is using. The virtual classes developed for desktop platforms would not allow the benefits of a client/server application. These facts apply to the underlying EMI Model as well.

Currently, a problem that multimedia development faces is the cross-platform aspect where porting an application from PC to Mac to a workstation depends on the availability of software from the same vendor to provide a relatively easy porting of the application. Since the main development of authoring programs is for PC and Macintosh, the cross-platform authoring is available from programs like Macromedia Director and Passport Producer among others [Macromedia95]. Compatible Windows and Macintosh versions allow the creation of an application in one platform and the possibility of running it in the other without many changes. However, there still exists the need of a program that offers a compact runtime module for the target platform. It is clear that UNIX-base development is out of the question. Some authoring software has been developed by Sun, SGI and IBM for workstations. However, they are very dependent on the architecture, and they do not provide means for cross-platform for PC or Mac. Waiting for the real cross-platform to come among the UNIX, Windows and Mac platforms can take some time. In addition, waiting for the products to be reliable and mature would increase the delay.

The VU project is not planning to dedicate its resources entirely to the production of compact discs to distribute the multimedia applications. Instead, it is planning to exploit all the resources the institution has. As in any other high-level academic institution, the access to Internet is a very important resource. Furthermore, the idea of publishing information through the World Wide Web (WWW) is a great alternative the project is considering. With the help of browsers like Netscape and Mosaic, the cross-platform access is guaranteed leaving out the problem of finding an authoring tool that allows the development for the WWW or waiting for the release of the long-term plan for Macromedia's Internet integration of Director's multimedia technology [Director95]. This is a project called Shockwave where the integration of Director and Netscape is now a fact.

Shockwave allows the creation of multimedia files which can be quickly transferred through the network using a compression technique for each of the formats used in a multimedia application (e.g. sound, video, text, still backgrounds.) However, the dependency on architectures and browsers could bring some troubles not seen ahead yet. Other alternatives arise with a strong influence such as the development of some of the virtual classes through programming in the Java language (SUN Microsystems).

According to Sun's expectations, Java will solve the problem of software incompatibility "giving users the option of downloading and running applications written for any system." [Gilliespie96] It is seen as the compliment to network-specific software. The final goal of the project at ITESM is to run its applications in the network allowing the access to these materials at any time from any place. The idea of the "network-centric" computer (NC) promoted by the chairman of Oracle Corp. and now complemented with the arrival of Java, confirms this goal. "What Chapman and other advocates of the NC envision is a future where the network is king, offering a vast web of inexpensive services that will be accessible to virtually the entire population." [Gilliespie96] The NC concept offers a connection to cyberspace for a much less amount of money than a computer and a modem could do. The main idea behind NC is a keyboard, a screen, a few megabytes of RAM and a connection to Internet through a fast microprocessor. The lack of peripherals will diminish the cost and the amount of software that a PC usually needs to operate. The NC will depend on the Internet to access applications and store information. Some implementations have been reported although the main companies are still working on their versions [Gilliespie96].

Right now, it can be said that Internet is not ready for such technology because the connections are not fast enough and are not that reliable; bandwidth speed and expansion are currently a serious restrain. However, AT&T, Digital Equipment Corp. and the MIT have already started working on this in order to come out with a solution. The expectations are to have infinite bandwidth that will allow "interactive multimedia and video to be in every household, via radio frequencies from satellites, wireless systems and fiber-optic cables."[Gilliespie96]" Internet will be the instrument through which the virtual university will become a reality.

On the other hand, Java can be seen as a language that assumes the availability of certain Internet resources. It is a language which focuses neither at the client side nor the server side but on how they perform through the network. That idea is the key in the NC concept where the network is the main focus. Besides, Java is an object-oriented
programming language like C++, but simpler, easier to use and overall very portable. Those three basic characterisitics make Java a powerful mean to do true programming surpassing the capacity of the HTML language that is just a limited mark-up language. From the point of view of the VU project, access to the multimedia applications developed for courses and seminars is very important as well as the portability of such applications. Java addresses the portability issue due to the fact that it is an interpreted language which hides particular characteristics of the computer architecture. The Java interpreter assures that the applications are hardware-independent. The interpreter receives the bytecode [Gosling95] which is "a high-level, machine independent code" and translates it to the machine code of the particular computer. Java makes this possible because it is based on the virtual machine concept, which assumes input-output devices in the computer that interact with the world. However, the concept is not concerned on how such devices work. Java utilizes the concept letting the hardware or application suppliers specify the particular implementation of such devices. In addition, the virtual machine concept does not try to use complex functions that can be performed by the different operating systems or acces features that particular hardware can execute. On the contrary, it tries to generalize the functions in order to simplify them. This allows the Java interpreter and applications to run faster even on machines that have slow processors or limits on peripherals. The security issue is still a point that has not been completely satisfied and has been addressed from several points of view [DoD85][Sun95][Dean95]. However the most important issue seems to be the security on the HotJava browser. Basically, the attacks happen when the access permissions are not well supervised by the browser. Another flaw is the trade-off between the openness of the applications by the Web developers and the security needed by the users of the Web. Despite of the possible flaws on security, Java imposes protection against viruses and attempts to avoid interference by using public key encryption [Hines96]. The inherent functionality between the NC and Java language makes them one of the more suitable options to reach the goals that the VU project has established regarding access to applications through the Internet. The entrance of AT&T to Mexico in the telecommunications market increases the expectation of using NC and Java, assuming that the bandwidth requirement will be there. However, the development of applications can not be held to these expectations. Therefore, the VU project is starting the development of prototypes [Espinosa94][Espinosa95a][Espinosa96a] that can be tested at the Campus using the current network infrastructure.

3. Hypermedia traversal detection through JAVA Applets
Since the approach taken by our team when developing the formal EMI Model was centered upon the freedom the student has upon the traversal of a hypermedia graph, the recursive model of Educational States (ES) [fully described in Espinosa96a] became a dynamic datastructure of undetermined length:

\[
ES = \left\{ \prod (TD \times TU \times TW) \right\} \rightarrow K_i \]  \quad (A)

As the PC-based hypermedia system operates, the datastructure is built. Refer to the companion article for the formal details of the construction and traversal. What this means in terms of implementation is that we need a series of agents [Director95] capable of detecting the following real time:

1. Identity of the student.
2. Student Profile [Boumedine96] [Espinosa96a].
3. Curricular status (ie. Prerequisites, taxonomical measurements, and timeline).

Attempting such agents on standalone PC’s is not a difficult task. The Hymerpedia software (ie. Mediaview, Microsoft) will enable the programmer to call Windows DLL’s, VxD’s or any other operating system gadget capable of interacting with the hypermedia software itself. The case study, however, determines that a Data Collection phase is required. Standalone PC’s will require a lab assistant to manually collect the EMI-generated datastructure from each station as the session ends. Human errors may occur since the identity of the student at the station may not be well known (ie. by errors in seat selection, computer failures etc.). When we connect the PC’s to a LAN or WAN, the issue of network connectivity, as described in the previous section, arises. We now turn to the WWW for a solution.

Java promises to be portable, distributable, secure, robust and easy to use [VanHoff1]. At the time of this writing, the Shockwave integration previously discussed has already started with the final-release of Netscape 2.0. Java applets are rapidly appearing in the public arena.
Using Java, we are devising a series of Applets we call EMIspectors. Each EMIspector resides in a HTML page, part of the [new] portable Datastructures II hypermedia, based on its PC counterpart. Its task is to detect the identity of the user traversing the page, as well as consulting an internal student database, which can later be consulted in order to perform the qualitative analysis EMI is based on. Consider Figure 1 concurrently with the discussions in the companion papers [Espinosa96a][Boumedine96]. A network of Educational States denotes the distributed nature of the datastructures material. The student is expected to log on into the network and traverse the course material. When the EMIspector recognizes the student as a Datastructures II one, the following info is updated in the database:

1. Time (eg. Hr/min/sec) of traversal.
2. Current ES.
3. Current TD.
4. Current TU.
5. Current TW.

![Figure 1: Operational Mechanism for the EMIspector Network](image)

The data need not be gathered manually by the instructor. Each local EMIspector will service a controller EMIspector (denoted as the database manager in emispector.ccm.itesm.mx). The service consists of a mail message being sent to the database manager as soon as the student enters a page - and the EMIspector is thus activated. This is currently being done using a link between the local emispector and CGI routines written in Perl. Implementation details follow in section 4. Currently, the Applets just serve as information agents. We are in the process of converting them into Intelligent Agents [Espinosa96c] which can then perform more complex tasks, such as showing a Reinforcement Unit thread, where the student may verify his/her level of comfort with the material just shown. A set of EMIspectors will act in coordination, but in a distributed fashion, in the processing of the recursive datastructure generated by EMI. Since we don’t want to mail or ftp the raw data to the database manager, we want each Applet to perform intensive computing on its portion of the job. This imposes several restrictions onto the community of local EMIspectors, all of which are subject of research and will be discussed in section 5, further work.

4. Current implementation of the Emispector Applets
Our current architecture involves two types of Applets: local EMIspectors dedicated to the gathering of information, and one central database manager, responsible for the collection of data. As said before, such a model is not fully distributed yet. As all Applets dealing with Internet, both types of EMIspectors are objects instantiated from a class derived from a fully operational Applet mechanism provided by SUN Microsystems. We introduce the EMIspector into each local HTML page (contained in hosts rembrandt, galileo and leonardo in Figure 1) that contains course material by including the following new tag command included with HTML 3.0 and currently available in Netscape 2.0:

```html
<applet code = "localemi.class" width=10 height=10>
<param name="station" value="rembrandt.ccm.itesm.mx">
</applet>
```
Note that the applet’s size is small and invisible (i.e. Presents no interaction to) to the student. It is not intended to show off graphics or sound. It is just a device used to silently record user activity on the HTML pages. It will even be hidden from the container HTML code it is embedded in. Such an applet is capable to record the four pieces of information listed in section 3.

As mentioned before, once the detection is made, transmission to the EMI manager is performed using a combination of Java Applets and CGI routines written in the Perl language. Such routines are invoked from a Java Applet using the following code:

```java
URL doc = null;
try {
    doc = new URL("http://www.ccm.itesm.mx/cgibin/EMInotifier?Conectado=" + paramval);
} catch (MalformedURLException e) {
    doc = null;
}
```

The relevant features of the Java Language used to complement the job are:
1. URL detection.
2. Code Base detection (i.e. the directory where the HTML page resides).
3. File I/O capabilities included in the Java specification

The information released by the local EMIspectors is captured by the database manager depicted as `emimgr` in Figure 1. Such an Applet performs the storage of all the data into a central database. This has proven to be costly and slow, given the large amount of information generated by the EMI datastructure. It has become necessary, therefore, to begin research in parallel processing in order to make a solid distribution of the workload.

The main console reveals the window into the EMI Model as perceived by the database manager. The intended user is the instructor, in this case. It can reveal him/her a series of behavior patterns emitted by any number of students as they traversed the course material. There is no restriction to time and place of this traversal. The Applet is also aimed at the simultaneous monitoring of several [virtual] courses.

It should be clear that the central Applet is a more complex one, requiring access to complete databases of information. For this reason, the `<applet>` tag used to integrate it to the respective instructor’s Personal (i.e. Private) Web Page, is also a more complex one. Curently, it looks like this:

```html
<applet code = "emimgr.class" width=10 height=10>
    <param name="station" value="emimgr.ccm.itesm.mx">
    <param name="matricula" value="matricula.mdb">
    <param name="perfiles" value="perfiles.mdb">
    <param name="emichain" value="emichain.mdb">
</applet>
```

5. Conclusions and future work: on EMIspectors
As the EMI model is validated [Boumedine96], the architectural specification will be tested under all possible conditions here at ITESM. These types of robots will eventually become intelligent agents which will be useful tools on the next generation of UV prototypes. The research on artificial intelligence, education, psychology, cognition and agents [Kaplan95] described in the main references at the beginning of the article will enable us to achieve a greater level of efficiency in the development of agents for the EMI Model.

1. They will have to perform parallel processing in order to register a consistent view of the EMI datastructure.
2. They will need to have access to [possibly] centralized educational and/or cognitive data.
3. They will provide advice to the student based on his/her own performance, while placing him/her in a situation where he/she will be able to make decisions directly affecting the outcome of his/her educational process.
6. Bibliography


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Abstract: The paper reports the preliminary results of a research project that investigates the phenomenon of disorientation in hypertexts. We present our experience in setting up a benchmark for measuring this phenomenon, and lessons learned regarding measuring the performance of people using hypertext technology in an educational environment. The project had two main goals: a) to identify the variables involved in the phenomenon, both those connected with the structure of the hypertext and those relating to the structure of the user's cognitive abilities; b) to find the best way to build a benchmark that identifies elements of a hypertext that may cause disorientation. This preliminary analysis used a "clinical" approach in evaluating data, in order to highlight the variables in operation. Although its findings cannot be supported by precise statements, one of the major preliminary results is the identification of seven possible categories of "hypertext user". We finally describe the main guidelines for further experiments we are conducting on these hypothetical classes of users to identify some remedies for disorientation.

1. Introduction

This paper describes the first results of research in progress at the Department of Computer and Management Science in conjunction with the Psychology Laboratory of the University of Trento (Italy). The research is a three years' project [Cast90] [Cast94] to study user disorientation in a hypertext environment and to understand the connection between the cognitive abilities of the subject and the navigation made in the hypertext. The study of disorientation in hypertext environments is a particularly complex undertaking, because of the large number of variables involved, and it has moved in different directions, ranging from cognitive field [Blak77] [Levi82] to adaptive mechanisms [Beau95]. A valid presentation of these different directions can be found in [Najj95]. Some of these variables concern the way in which the hypertext is constructed and presented. Another group of variables relates instead to the capacities and/or skills employed by the user when navigating the hypertext; of these, cognitive abilities are particularly important. We set out below the first results of a pilot experiment designed to analyse disorientation with a twofold aim: a) to isolate a number of important phenomena connected with the variables outlined above, and b) to calibrate the experimental structure itself in order to optimize the construction of a benchmark.

2. Structure of the experiment

The approach used in this preliminary study took more the form of a pilot experiment than one designed to test a set of concrete hypothesis. It had two main goals: a) to single out the most significant factors in hypertext performance; b) to measure the influence of cognitive variables on performance. Although the aim of work in progress is to gather data on four levels of schooling (elementary, middle school, high school, university), for a total of 200 subject, this paper gives the results relative to a first group belonging to the first band. In fact, tests were submitted to 40 subjects, but the data given here refer only to the 15 subjects (9 males and 6 females) who satisfactorily completed all the tests. For the purposes of the experiment, we built an hypertext which gave priority to spatial relations, although the temporal dimension was also present. In parallel, three psychological tests were selected which measured the subjects' cognitive abilities.

In order to isolate a number of variables that we believe influence a subject's performance on a hypertext, we used three cognitive tests: Raven's Progressive Matrix (abbreviated PM) [Rave87], D.A.T. Spatial Relationships...
(abbreviated SR) [Benn59], and Witkin’s Embedded Figure Test (abbreviated EFT) [Witk71]. On the basis of these tests, we located the following six variables, or cognitive factors, that in our opinion are crucial to evaluation of good hypertext management: intellectual efficiency, analytical ability, analytical flexibility, synthetic ability, abstract reasoning, cognitive field independence [Cast91].

The second part of the test was the hypertext "Alligator", a simple hyperstory that takes the form of a collection of information and evidences, all of which has a bearing on the hunt for a fugitive bandit. The "hyperstory" is set on the island where the bandit is now in hiding. The statements given by witnesses constitute the nodes of the hypertext, and it is the user's task to move as efficiently as possible among these nodes until he finds the bandit's present hideout. The hypertext therefore takes the form of a maze in which a certain number of objects, concepts, characters and situations are called, in our terminology, marks [Cast90]. The names of the characters, events, the time at which they occurred, the geographical references, the statements made by the story's various characters, are all elements which must be organized in order to find the solution. These information sources are the marks of the hypertext. They can be signifying marks (useful for solution), structure marks (the buttons and the hotwords which enable to navigate through the hyperstory) or noise marks (misleading information, false trails, any fact which is not relevant to the solution and which may lead the user astray). In the hypertext each item of information (piece of evidence, photograph, map of the island, etc.) constitutes a single page. The various pages of the hypertext are catalogued in six groups (cover pages, witness pages, etc.), in a way that is transparent to the user and only for the purposes of analysis.

Fig. 1 - The cover page for the witness statements

Fig. 2 - A witness statement

The hypertext is mainly hierarchical in structure, and uses geographical access as its metaphor. The user navigates to the witness statements via "geographical access points"; i.e. the places at which the evidence was collected. From a general map depicting the area in which the story takes place, the user descends to one of the four areas (north-west, north-east, centre and south) into which the island has been divided. It is possible to descend to a further level of detail, for example the map of the main town of the island. It is always possible to return from these two latter levels to the higher level (the initial map). The texts of the witnesses' statements are preceded by a cover page which aggregates the statements collected in a particular place (see Fig.1). The user can return from this level to the one above it, or else he can access the texts of the witness statements by means of the hotwords corresponding to the names of the witnesses. A witness statement (see e.g. Fig. 2) is accompanied by information about the witness, the day and the time being referred to.

The experiment was conducted with a sample of two classes from a middle school in the city of Trento in four stages: a) the three cognitive tests were administered in classroom, during two hours of the normal school day, by the psychologist who subsequently calculated the results; b) the subjects worked on the hypertext in the Dept. of Computer and Management Science of the University of Trento. There were no time restrictions, but the subjects took between one and a half hour and two hours to perform the task. The observer gave only general and pre-established instructions; c) assessment was based on analysis of the moves recorded by a program during their performance. This stage consisted of a “clinical” analysis of the data, rather than the statistical processing of the parameters, because of the pilot nature of the study and the smallness of the sample; d) The subject's cognitive abilities were cross-referenced against his performance on the hypertext.

3. The results
We decided to aggregate the phenomena observed by describing certain categories of hypertext performer, bearing in mind the subjects' results on the cognitive tests. Before presenting this "clinical" assessment by category, we give a brief outline of the general characteristics of performance on the hypertext. The details of the subject performance are reported in [Cast94]. In order to facilitate assessment of the user's performance, all the hypertext objects of use to the benchmark are given a name. In this way, all the moves made are identified by the name of the object used. Thus assessment of user performance is based on raw data about his personal details (age, etc.), psychometric test results, structure of the hypertext, moves made during the navigation, and his solution. Elaboration of the raw data and a certain amount of aggregation yielded a set of indices relative to:

1. number of moves, distinguishing between navigation nodes and witness statement nodes. This allows discrimination among subjects according to the way in which they handle the context and the content.
2. repeated visits to a node, also considering distances (in terms of moves and time) among various recurrences;
3. coherent moves: each move was assigned a positive value if it was made coherently with the information possessed at that particular moment, or if it expressed a choice made on the basis of coherent reasoning.

Another interesting parameter is the author's time, which refers to a reasonable time necessary at least to read the content of the node. It allows calculation of a difference with respect to the time spent on a particular node, and is a crucial contribution to our understanding of user's performance. We stress, however, that this parameter requires further study and careful use. The determination of a value for each node depends partially on a subjective evaluation of the authors. However, the manual estimation of this parameter based on our experience was unexpectedly precise. In fact, variations with respect to the author's time were so evident that we were able to distinguish which subjects were in the range of author's time and which were outside.

3.2 Patterns of performance

We now present the categories into which our pilot sample can be classified according to an interpolation of their cognitive and hypertext performances. The categories range from the least efficient subjects to the most efficient ones. They are simply an attempt to describe how the subjects characteristically performed on the cognitive tests and the hypertext, looking for relationships and contrasts that may yield information on the ways in which the two sets of variables - relative to the hypertext structure and to the user's cognitive abilities - interact. Our classification of subjects, based on some hypertext performances, is similar to the clusterization that has been carried out in [Reck94], though obtained with different criteria. Our grouping was been made by hand, not with statistical analysis, looking move by move at the subjects' performances. This was done to attach the optimum level of understanding of the correlations between cognitive variable and user's navigation. This "time-consuming" approach allowed us a better "tuning" in the comprehension of the subjects'behaviours.

a) The "over inclusive" subjects. Low cognitive performance: low analytical flexibility and confused synthesis procedures, as well as problems in handling processes of logical inference; logical errors in discriminating between important features and details. They somewhat better scores in spatial relationships indicate that they were more inclined to address the practical aspects of the problem. Low hypertext performance: reveals a component of disorientation, but also low attention level and superficiality in analysis of the contents; lack of discriminatory capacity. The analysis of the performance highlights: a) frequent jumps without logical or spatial coherence: non-control of context more than a failure to understand the nodes; b) nodes mainly chosen at random; c) constant consultation of the general map: possible sign of context-dependence and disorientation; d) less time devoted to global reading of the hypertext: incapacity to discriminate important information. These subjects attempt to manage a complex situation by lumping all its elements together indiscriminately.

b) The consciously disoriented subjects. Average-low cognitive performance. limited analytical capacity, with fewer logical errors, most of which due to their inability to apply an appropriate logical principle. Average-low hypertext performance: a) a great deal of time devoted to understanding the context: poor control over the context with some sort of "disorientation" awareness; b) frequent loops without re-reading a text: no adequate processing of information; c) frequent aimless wandering through the maps: influence of the geographical-spatial aspect of the hypertext and an attempt to control the external features of the hypertext. This group seems the one that best represents the category of the disoriented. Their concentration on navigational aspects distracted them from the search for, and the acquisition of, the information required to accomplish the task.
c) The unconsciously disoriented subject. Divergent performance on the cognitive tests: better results on the SR than on the PM test; constant oscillation between answers and a partial fall-off in performance, perhaps due to lower analytical flexibility. Average hypertext performance, with misunderstandings: a sort of “hastiness” influenced their path: a) a high rate of re-readings of the witness statements, due to two factors: recognition of importance and, in parallel, haste and/or superficiality; b) control of navigation is conditioned by the same factors (after re-reading the instructions, they began to use the maps better). As in the previous case, this class is unable to control the context satisfactorily, and fails to recognise this lack of control, thus not devoting time and resources to controlling it. This unconscious disorientation causes problems in logical connections.

d) The short-term coherent subjects: Divergent performance on the cognitive tests: much better spatial abilities than general cognitive efficiency; errors in analysis and flexible use of context elements; orientation to some kind of concrete intelligence which allows better control of sequential structures. Fair but incoherent hypertext performance: a) few navigational hesitations, but incoherent performance increases as far as the cognitive overload increases; b) the awareness of the skills in controlling the spatio-geographical dimension induces to comparative neglect of the logical aspects of the information nodes. The ability to interface with the hypertext structure seems to be a factor that both facilitates and restricts the performance. Pushing to its limit, we may say that from a certain point onwards the subject stopped checking the information and instead concentrated on the "topographical" links among the witness statements that he regarded as significant.

e) The spendthrift subjects. Quite good cognitive performance. Good capacities of analysis and synthesis but limited flexibility. Average but laborious hypertext performance. a) performances disappointing with respect to the cognitive abilities: a constant oscillation between disorientation and attempts to gain control over the context; b) little coherence in move sequences: navigation with random use of a "review" strategy and with no reliance on logical inference. The subjects made limited use of their own potentialities and of those present in the hypertext structure, probably because they lacked faith in their ability to master the new context.

f) The quasi-independent active subjects. Generally good cognitive performance. Good general efficiency, notable analytical and synthetic capacity, precision in the application of abstract thought and logical inference; some weakness in spatial orientation, but few errors. Quite competent hypertext performance: a) adequate competence in controlling a new and difficult context; b) direct control of the hypertext situation less conditioned by the hypertext context: the subjects filter the information available at the nodes, establish its importance and then decide the level of attention. This performance is characterized by competent interactive behaviour. However, it shows some fall-off in efficiency, due mainly to the complexity and unknown context.

g) Potentially good performers. Very good cognitive performance. Excellent general efficiency and well-integrated analytical and synthetic skills. Good hypertext performance, with some flaws. a) efficient navigation through the hypertext, with evident use of cognitive capacities; b) use of the navigational structure strictly functional to the task; c) frequent progress checking, by comparing connected or partially contradictory information. They can exploit a hypertext structure well and, as already said, provide the best evidence of the extent to which the good cognitive abilities that we identified influence successful hypertext navigation.

4. Preliminary considerations about performance

At this point, we set out some general considerations about our experiment and the disorientation phenomenon, rather than clearcut conclusions based on statistical verification. These hypotheses will constitute the basis for our future study of how users "get lost in hyperspace". As a general consideration, we realized that it is very important to make a video recording of the experiment. The visual impressions gained from observing subjects confirmed our preliminary findings, and if supported by a video recording they would have provided a further source of information with which to correlate the various phenomena.

Geographical vs textual hypertext interface. A first hypothesis concerned the ratio between the navigation pages and the witness statement pages visited, in terms of number of page visited and time spent on the different type of page. We believed that text pages require more time to be read than a “geographical” page. The hypertext contained roughly the same number of navigation and witness statement pages, but its hierarchical structure obliged the user to make a series of geographical moves to reach the witness statements. Thus, a prevalence of visits to the navigation pages (a ratio of about 3 to 1) was to be expected, balanced by less time spent in the geographical pages. These expectations were confirmed to an extent even greater than expected. The subjects were therefore largely influenced by the structural aspect of the hypertext, and devoted more energy to
controlling their navigation than to reading the witness statements. The novel aspect was that subjects spent more time on navigating than on reading the witness statements. The geographical page was not only the most frequently visited node (due to the above consideration on hypertext structure). It was also the point at which subjects gathered their thoughts, reflected and then decided on their next move. Examining a text page seemed to require reading and acting, disabling this activity of information storage. We have (very empirically) noted the same phenomenon by observing people in the navigation through WWW pages. These preliminary results seem to confirm the risk involved in introducing more and more sophisticated navigation mechanisms into the hypertext: namely that the user's attention will be diverted from informational features to navigational ones. Another open issue is the novel aspect of a different kind of "disorientation" from that traditionally described. Although the users were largely unaware of it, they were "reoriented" towards mastering the hypertext structure rather than its informational content. This phenomenon may be flanked by (and often reinforced by) the self-satisfaction felt by users on mastering the navigation structure.

User’s hastiness. Another interesting observation concerns the hastiness with which the nodes were read. High values in the differential between parameters author’s time and reader’s time, may indicate a "review" navigation strategy, which scans all the nodes in rapid sequence. When the subjects took notably less time than that established by the author, this probably indicated "hasty" reading. As the lower limit we adopted a "physiological" value, i.e. the amount of time under which any reading is without meaning (about 10 seconds depending on the length of the node). When, at the other extreme, the subject took 50% more than the author time, we presumed that the subject lingered at the node, because he found it difficult to comprehend or had problems in processing the information. The intermediate time band may represent performances in line with what the author considers to be competent. The results of the subjects’ performance show a wide variety of behaviours. We therefore found more problems than expected, and the original hypothesis must be refined with further studies. By clarifying certain aspects of this relationship between time spent and type of node, we may reflect productively on the implementation of didactic hypertexts or, at any rate, on the best way to structure knowledge corpora for hypertext purposes.

Differences between sexes. An interesting datum is yielded by comparison between performances by male and female subjects. In general, we may state that females perform significantly better than males on both the cognitive tests and the hypertext. As regards the cognitive tests, females achieved better results in general efficiency, while they performed worse in spatial relationships. Given that the literature stresses a considerable difference in the spatial abilities of the two sexes (lower for females of all ages compared with males [Wils75] [Vand78] [Beat87] [Vand78] or at any rate more closely correlated with masculinity [Newc83]), it is interesting to note that females perform better on a hypertext with a strongly geographical-spatial structure. Hence, on the one hand, it seems that the greater ability of the males to control the spatial dimension induced them to devote more time to spatial exploration of the hypertext. On the other, the greater attention paid by the females to the verbal components of the task, together with their greater logical efficiency, enabled them to perform better, despite the importance of the hypertext's spatial structure. Females devoted more time and more attention to texts, while the males performed better in navigation. The females' greater concentration on the problem and their lesser distraction, moreover, was reflected in their cognitive performance: on both tests (PM and SR), they gave a lower percentage of wrong answers. It should be stressed, however, that the differences in application and performance may have been due to the age of the subjects, which display different features in the males and in the females. The girls were at the post-pubertal stage: they were emotionally calm and, hence, more cognitively self-composed. The boys had mostly reached the full pubertal phase and were therefore more emotively and cognitively unstable. This would explain their lower level of concentration or, conversely, their greater lack of control over their cognitive performance. Certainly, we have to create wider samples in terms of ages, but we should bear in mind that the differences found between the sexes are not trivial.

Loops. A "loop" consists of repeated visits to a node and warns the observer that the subject may be disoriented. A subject who re-reads an already visited node, particularly a witness statement, may no longer be able to master the context in which he is moving. In effect, returning to a witness statement may be a symptomatic of various phenomena: a) the user wants to return to a previous spot; b) he has forgotten that he has already visited the witness statement; c) he has reached it by mistake (i.e., clicking the wrong button); d) he wants to re-read it to gain fuller understanding of undervalued concepts; e) he wishes to compare information apparently connected and/or contrasting with those of current node. Except for the first situation, the "distance" between two visits to the same node is important in determining the situation of the user. Once he has returned to a node, the subsequent behaviour may help to clarify the reasons for the move: 1) the user immediately leaves the node because he realises that he has already read it; 2) the user halts for an apparently anomalous amount of time (< author time) because once he begins reading the node he remembers having already seen it; 3) the user
spends a long time ( > author time) on the node in order to study its content 4) the user stops a long time ( > author time) because he does not remember having read it.

With the data available, we can outline an explanation for this behaviour using the parameters for the amount of time spent at the node, for coherence of immediately preceding and following moves, and the number of iterations already made to that node. The main combinations of these parameters are shown in Table 1.

<table>
<thead>
<tr>
<th>time spent</th>
<th>move coherence</th>
<th>orderliness</th>
<th>situation</th>
<th>evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>positive</td>
<td>low</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>low</td>
<td>positive</td>
<td>low</td>
<td>1</td>
<td>B</td>
</tr>
<tr>
<td>below a.t.</td>
<td>positive</td>
<td>high</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>below a.t.</td>
<td>negative or neutral</td>
<td>high</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>low</td>
<td>negative</td>
<td>high</td>
<td>1</td>
<td>D</td>
</tr>
<tr>
<td>high</td>
<td>negative</td>
<td>high</td>
<td>3</td>
<td>D</td>
</tr>
</tbody>
</table>

The two best situations (A & B), despite their causal differences, may be symptomatic of the subject's loss of bearings and his attempt to regain control over the context. Both could represent subjects with a "physiological disorientation" that is not harmful and which may be of help in dealing with situations of uncertainty. Subjects in the other categories, instead, are probably disoriented to varying degrees of "seriousness".

If it makes sense to disaggregate the disorientation phenomenon in this way, and our first findings seem to confirm it, there is an important practical conclusion. The provision of navigation support mechanisms to prevent disorientation may produce different effects, depending not only on the "degree" of user disorientation but also on the moment at which these mechanisms are provided. For example, two subjects in situations A and B will probably react in different ways to a navigation support like a "history list": the subject in situation B may find it superfluous, whereas the subject in situation A may find it almost indispensable. As already said, one of the target of the next benchmark will be finding the right navigation support at the right time. Regarding "loops", we want to gather more information by means of further experiments. Better knowledge of this phenomenon could lead, in fact, to the introduction of adaptive mechanisms. For examples, the detection of a loop by the hypertext system could act as a "ringing bell" that triggers an "agent" incorporated into the system. The task of this agent would be to propose a new way of navigating, to advise the user about his moves, to suggest better moves based on author "guided tours" or whatever.

The structure of the hypertext The mainly hierarchical structure of the hypertext did not seem to help subjects to understand the context. This was another surprise: we were convinced that, given the simplicity of the approach, a tree structure would have been of great help to overall performance. Instead, even those who mastered the navigational structure committed performance blunders based on the "passive" strategy of simply moving to the "nearest" place in the hypertext. Although this behaviour may have been due to the rigidity of the hierarchical structure, other factors emerge from our analysis: a) subjects showed a consistent tendency to use serial mechanisms in "browsing" the buttons of a map, lists of various kinds, series of graphic objects, etc. This browsing technique, limited to the visit of the nodes, has been also highlighted by [Reck94] as "a default novice navigation strategy"; b) they tended occasionally to concentrate on information which they associated because of some similarity. The first kind of behaviour seems to stem more from the subjects' traditional approach to a "book" already structured by the author, than from the hierarchical structure itself. It is therefore probable that the negative effects of this kind of approach (mainly carelessness and fatigue) can be corrected by fostering a "hypertext philosophy" of how to handle a knowledge corpus, rather than by developing further navigational mechanisms or different structures. As regards the second kind of behaviour, however, our analysis suggests that a different kind of structure may indeed be more appropriate. Between an openly reticular and a hierarchical model, in fact, there may be room for a "cluster" model, consisting of a partially hierarchical framework with branches radiating out to information nuclei aggregated by similarity (by content or by class).

Space and time Although a structure based on the prevalence of spatial elements undoubtedly influences the user, the direction and characteristics of this influence are not unequivocal. Our preliminary analysis revealed two major inconsistencies, partly already highlighted: a) subjects less endowed with a capacity for spatial representation (mostly females) achieved the best results in interacting right with this spatial structure; b) greater mastery of the spatial dimension (especially among the males), "distracted" their attention and sometimes led to disorientation. It seems that a user can correlate the spatial structure with the relational structure of the contents.
of the hyperstory only by undertaking a massive cognitive processing. Further light should be shed on this matter in the next stage of our research project, where we plan to use a version of our hypertext with a predominantly temporal structure and with subjects of different ages.

Other cognitive variables First of all, the cognitive variables initially identified have demonstrated their utility in the study of the phenomenon. In particular, general intellectual efficiency, analytical and synthetic ability, and finally analytical flexibility seem to have major influence in determining the quality of the performance. Our experiment substantially confirmed our expectations of a correlation between these cognitive variables and performance on the hypertext. Similar results have been outlined by [Reck94]: "the higher-ability subjects (...) in the hypertext condition made significantly less errors (...) than the low ability subjects". This is, however, a "not perfect" relation, probably due to both the small size of our sample and to our decision to concentrate only on certain (but important) variables. In this sense, however, our data indicate other areas of ability in which other significant variables can be searched for: "memory" being the major case in point. Many of the phenomena that emerged in hypertext performance did not correlate, or correlated only partially, with the cognitive data. In the case of loops, for example, the importance of preceding and following moves in defining loops, inevitably introduces the role of memory (type and amount) in characterizing the subject's performance. The role of memory in storing what has been seen and what remains to be seen is also cited in [Reck94]. Memory, in both its traditional definition as a system of information retention and also as the "central calculation space" [Pasc84] or "working memory" [Case85], may be the variable that differentiates the hypertext performance of subjects who otherwise have similar cognitive abilities.

5. Conclusion

We have presented our experience in setting up a benchmark for measuring and studying the phenomenon of user's disorientation in navigating through a hypertext. The analysis of the subjects' behaviour has confirmed some hypothesis, and revealed some others that will be explored further in the next experiments. These hypotheses regard the differences between sexes in using a hypertext, the real role of a geographical metaphor as an aid to the navigation, the correlation between cognitive capabilities and performance on the hypertext. Though our sample was limited, the first results have suggested us that we should concentrate attention in future experiments on such specific aspects as: 1) the influence of different structures of the hypertext; 2) the influence of the "field-dependence" variable; 3) the role played by memory factors; 4) the time metaphor vs the spatial metaphor in constructing hypertexts. Moreover, we have categorized the behaviours of our subjects in seven groups with specific characteristics and specificity. Our next experiments will involve more subjects of different ages, and will concentrate on testing the consistency of the proposed categories, in order to analyse the appropriate remedy for the disorientation phenomenon.

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Experiences in Evaluating Electronic Books: Hyper-Book and Cesar

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Abstract: This paper presents some general guidelines for electronic book evaluation, which have been drawn from two experiences of electronic books, Hyper-book and Cesar. Hyper-books are electronic books based on the paper book metaphor and designed to be part of an electronic library. Cesar is a hypermedia learning environment for deaf children, based on electronic stories. Taking into account the stage of development of the systems, the available resources, and the kind of end users, Hyper-book has been evaluated using an empirical method, while an expert method has been applied for Cesar evaluation.

Introduction

The development of new information technologies (e.g. magnetic and optical discs, high-speed networks) has opened new possibilities in order to produce and disseminate information. Paper is just one of the options for publishing; however, more and more information is now organised and distributed in electronic form. One possibility for presenting electronic information is by means of electronic books. They are information delivery systems that are capable of providing their users with access to pages of reactive electronic information with which they can interact [Barker 1993]. These pages are conceptually organised like the pages of a paper book.

The underlying philosophy of electronic books is maintaining the book metaphor. "Metaphors are analogical models to something existing outside the domain to which they are applied" [Väänänen 1995]. They provide a model with which users are familiar in order to enable them to exploit their existing knowledge from other domains, when learning to use a system [Carroll & Olson 1988]. The use of the book metaphor allows a familiar environment to be created, where the user can easily know where he/she is, how to reach another location (e.g. a specific chapter, the index), and what he/she can do.

The fact that electronic books are based on the book metaphor is not sufficient to guarantee that they are really familiar and easy to use; it mainly depends on the degree of adoption of the metaphor. As any other system, electronic books need to be evaluated. Evaluation is primarily intended to identify and rectify usability deficiencies existing in computer based and electronic equipment [Rubin 1994]. A system which is under development, should be gradually improved through a process of design, test and redesign, which is called iterative design.

There are different methods which could be applied for evaluating a system. The most common are [Benyon et al. 1990]:

- analytic evaluation, which uses a formal or semi-formal interface description to predict users' performance in terms of the physical and cognitive operations that must be performed. It can be used early in the design cycle and does not require costly prototype and user testing;

- expert evaluation, where experts are asked to judge the system and identify the potential usability problems, taking the role of less experienced users. This method is quite cheap and efficient, since a small number of experts can detect significant problems. This method can be used on first prototypes or system specifications;

- empirical evaluation, which involves participants who are representative of the target population to perform a series of tasks. This method is quite expensive compared to expert evaluation, because it can be applied only when the systemanalysed is considered ready to be presented and satisfactorily used by the final user;

- experimental evaluation, in which the evaluator can manipulate a number of factors associated with the interface design and study their effects on various aspects of users' performance.

The choice of a particular method mainly depends on the stage of development of the interface, the extent and type of users' involvement, the kind of data expected, external limitations such as time constraints, cost and availability of equipment, etc.

In this paper the problem of electronic books evaluation is discussed, through two different experiences, Hyper-books and Cesar, in two different contexts, electronic libraries and learning respectively. In the following sections the two systems and the results of their evaluation are described. Finally, general guidelines for electronic book evaluation are drawn from these two experiences.
Hyper-Books

Hyper-books [Catenazzi & Sommaruga 1994] are electronic books designed to be part of an electronic library, hyper-lib [Catenazzi & Sommaruga 1995], and some of their properties are dependent on this feature. Hyper-books provide facilities useful for consulting the book (browsing), for locating a specific information (searching), and for a more detail study if the book results to be interesting (personalisation and printing).

They can be presented closed, with the front or back cover in view, or open, with two pages presented at a time [see Fig. 1], in accordance with Benest's model [Benest 1991]. The position within the text is clearly indicated by the thickness of the pages at the two sides. Pages are designed following the traditional model: they consist of a header, where, for instance, indications about the current chapter are given, a footer where the page number is located, and the main page corpus, which contains text and graphics. The combination of these elements (i.e. thickness, page design, etc.) provides important clues in order to avoid disorientation when using the book.

With respect to the functional aspects, hyper-books inherit from paper books several functions, such as the possibility of moving in the text in the classical linear way, i.e. turning or flipping pages, and the possibility of personalising the book material. In particular, figure 1 shows how the hyper-book user can type his/her own annotations on the pages which are currently open, add personal comments in an overlapped window, and insert bookmarks to mark relevant pages, without altering the original copy of the book for another user of the library collection.

![Figure 1: A hyper-book page](image)

Although we recognise the importance of maintaining features and functions of a paper book in electronic books, the simple simulation of a paper book is unlikely to succeed. The result would be a second-rate book. By exploiting the underlying technology, new tools and properties are added in order to create a powerful, flexible, and interactive object, without significantly altering the book interface.

For example, an interesting hyper-book feature is the provision of links, i.e. active areas that are connected to other parts of the book, or to other books in the library. Other active objects are the thickness of the book and some buttons which provide access to special locations, such as the Table of Contents and the Index. A backtracking mechanism allows the reader to go back to the page where the link has been activated.

Another facility which is available in hyper-books is a search tool, which allows a term or a combination of terms to be searched in the whole text of the book. This offers a new form of finding useful material, in addition to the traditional methods provided by the Index and the Table of Contents. Other facilities are available to increase the flexibility of the system, giving access to resources which are outside the hyper-book system, such
Hyper-book Evaluation

The objective of the hyper-book evaluation was to verify that the system is easy to use and understand, to a similar degree by everyone, regardless of his/her computer expertise.

With respect to the evaluation methods previously presented, and considering the stage of development of the system, the most appropriate way for evaluating hyper-book emerged as being an empirical evaluation. In particular, the observational and survey techniques have been used. The observational technique aims to collect data about the user's behaviour while using a system, and makes use of several strategies, such as direct observation, video recording, software logging, and verbal protocols. Survey evaluation involves the use of interviews or questionnaires with the purpose of eliciting users' subjective opinions and understanding of the interface.

The system evaluation involved two groups of users, with different computer experience. They were classified as computer experts and non-experts. Their performance was compared in terms of executing a number of tasks, which are representative of typical tasks a user performs with books in a library. They include browsing, searching, and analysis. In the browsing task the user was given a general topic, and he/she was asked to find out if and where the topic is discussed in the collection. This task requires ability to consult a book in order to have a general idea of its contents. In the searching task the user is asked to answer a specific question using the information contained in the book. This is usually the case of a user who has some knowledge of the book's content and wants to retrieve a specific information. In the analysis task the user has to analyse a topic discussed in the collection and select the most relevant parts. This could be a typical problem of a researcher who has to use some documents as a reference material for a paper.

For each task, three aspects were considered: how well it was accomplished (quality); the time required to accomplish it; and which tools were used and how often.

On the basis of the hyper-book evaluation results, it emerged that both groups achieved a good performance and no evident difference in quality and time arose. Therefore, computer expertise does not represent a significant aid in order to perform better or execute tasks quickly. These results lead to the conclusion that the system is easy to learn and use by everyone, and it is appropriate to employ the book metaphor. Other interesting results arose from the analysis of the tool usage, which gives an indication of the users' strategy in executing a given task. This strategy depends on two factors: the nature of the task and the experience of the user. For example, computer experts preferred to use searching rather than navigation tools because they were already familiar with them; on the other hand, computer non-experts tended to use navigation, which is closer to the strategy adopted with paper books. In general, people tended to employ those tools which were more obvious and self-evident according to their previous experience. The hyper-book system provides tools in order to meet different needs and habits.

Cesar

Cesar [Aedo et al. 1995] is a hypermedia learning environment for deaf children, based on electronic stories. The basic idea is to provide a familiar environment where children can learn, and enjoy themselves. The cardinal element of the system is the electronic book, which is organised as a sequence of single pages, starting at the front cover and ending at the back cover. Figure 2 shows an example of a typical page. Starting from this basic model based on the paper book metaphor, the electronic book has been enriched with several features which are provided by the electronic technology, such as multimedia and links. For example, the story is displayed not only in textual and graphic forms, but also in video form. The video shows a narrator signing the story. The highlighted terms in the text provide links to synonyms.

The child is also provided with different navigation mechanisms. In addition to the traditional capability of turning pages, he/she can also go to a specific place in the book by using the bar at the bottom of the page, by selecting appropriate buttons (e.g. the front cover button), or by activating bookmarks previously inserted.

Since Cesar has been conceived to be an open environment, access is also provided to external resources, which are considered useful to support the learning process. They include, for instance, a dictionary, which helps children advance in the language learning process. In addition, in order to allow the child to express his/her creativity, a personal note-book and a drawing-tools box, containing a pencil, a highlighter, a ruler, and an eraser, are provided.
As any study book, Cesar includes a training section, containing a set of exercises. In particular, these exercises are oriented towards acquiring the necessary competence in both sign and written language, taking into account the kind of users to whom it is addressed. When a child has to do an exercise, he/she is first presented with a simulation, which indicates how to solve it, and then he/she is invited to do it alone.

An important aspect which has been considered in Cesar are the different learning styles of the users. Cesar includes mechanisms which permit to adapt the environment to the specific user’s needs and characteristics, giving priority to different elements (e.g. image, sign language, written text) according to the child’s level. In particular, three main levels in the deaf children’s education have been identified, including an initial, an intermediate, and a high level.

Cesar evaluation

The objective of Cesar evaluation was to demonstrate that using electronic stories in a hypermedia learning environment can help hearing-impaired children in acquiring the necessary skills in sign and written languages.

Taking into account that the Cesar system development, even if reasonably advanced, is still not appropriate for the presentation to the specific users, i.e. deaf children, and considering the available techniques, the most suitable method for evaluating Cesar was found to be the Jogthrough technique [Rowley & Rhoades 1992]. This is an expert evaluation method which involves a multi-disciplinary team of experts who are asked to judge the usability of a system and to detect significant user interface problems.

In Cesar evaluation the group of experts consisted of two computer scientists and two deaf children’s teachers, who had to express their opinion about the system, taking the role of less experienced users. The experts were presented with a set of tasks, which the system allows to achieve, and a questionnaire, which contains a set of questions related to the tasks. For each task, they were asked to answer a set of questions in order to detect the possible problems in the user interface and estimate the percentage of users which are likely to have problems. Two groups of tasks have been considered: tasks involved in the system functionalities (functional related tasks) and tasks related with the child’s learning process (learning related tasks). Functional related tasks were selected by grouping actions that make active use of the environment (e.g., navigational operations). On the other hand, the actions related to information learning were grouped in order to choose learning associated tasks.

The results of Cesar evaluation [Aedo et al. 1996] confirmed that the use of the electronic book is a good choice, because it creates a familiar environment, where children can navigate without getting lost, and they are aware of what they can do because they map familiar concepts in the computerised environment. In addition, it limits the cognitive overhead associated with having the computer as an intermediary between readers and system. This is extremely important in situations where user is not a computer expert. Another important result is that the flexible interpretation of the book metaphor, allows the system to be suitable for different users’ learning styles. In particular, the use of multimedia enhances the paper book metaphor, taking maximum advantage of the visual learning channel. Multimedia contents have a direct impact on the students, because not only they make
the environment more attractive, but also they can quantitatively and qualitatively reinforce memories and thereby improve learning.

General Guidelines for Electronic Books Evaluation

The lesson learned from these experiences allows to define a general procedure in planning an electronic book evaluation.

• The first step is the definition of precise, accurate, and clear objectives. The choice of the objectives is dependent on the application goals and affects the successive selection of tasks [see fourth step].

• The second step is the selection of an appropriate technique, according to the system stage of development and the resources available, as previously described. There are no specific techniques for electronic book evaluation.

• The third is the selection of evaluators, which can be experts or real users, according to the chosen technique. Experts evaluators have to be able to take the role of real users when interacting with the system. When evaluators are real users, they have to be a sample of the target population, and the testing environment has to be as realistic as possible.

• The fourth step is the selection of tasks: it is important to separate those tasks which are dependent on the application, and those dealing with the actual use of the book. While it is not possible to give general guidelines for the selection of the first group of tasks, because they are strictly related to the application domain, for the second group general tasks can be suggested. Typical tasks can be:

- browsing, i.e. navigating in the book, which includes sub-tasks such as turning pages, activating links, selecting bookmarks, back-tracking, etc.
- searching, i.e. looking for a particular information in the book, which includes sub-tasks such as searching for specific strings, searching for object attributes or structure, natural language queries, etc.
- personalisation and elaboration of the book material, which usually involves the use of external objects such as word-processors, drawing tools, encyclopaedias, calculators, etc.

These tasks are dependent on how the electronic book has been implemented and to what extent the traditional book features and functionalities have been maintained.

• The last step is the choice of the quantitative and qualitative data which have to be collected and elaborated, in order to draw conclusions taking into account the initial objectives. Quantitative data can derive, for instance, from performance measures such as quality and time which provide an indication of the system usability (e.g. how easily the users found it to perform each task, etc.). Other interesting data can be drawn from the frequency of the tool usage, which is useful in order to investigate the user’s strategies while executing their tasks, and, in some way, provides an indication of the utility of the single tools in the system. A very important contribution is also brought by qualitative data, which derive for instance from verbal protocol (where the user is invited to think aloud to express observations and thoughts), and from open questions of interviews or questionnaires, which need to be appropriately designed. The preparation of interviews and questionnaires is an important task, which has to take into account factors such as the objective of the system, the type of users, and has to produce the expected data. The choice of quantitative or qualitative data usually depends on the selected techniques. For instance Jogthrough mainly produces qualitative data.

The previous steps have to be interpreted as general suggestions. A great burden in the evaluation design is the application domain, including the kind of users. In addition, there are several other evaluation techniques which could be used. However, we have presented here two examples of techniques which have demonstrated their validity and effectiveness in two practical cases.

References

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Efficient Methodology for Automatic Video-Content Indexing and Retrieval of Lectures for CAI Systems

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Abstract: An efficient methodology for automatic segmentation and indexing of digital video is presented in this paper. This approach is specially-designed for manipulating lecture video to construct interactive learning systems. In this methodology, video shot boundary could be detected automatically according to slide changes in a lecture without using any pre-defined image models. Representation frame is selected automatically for each video shot as video index. Lecture text would be used to assist in extracting video content in lectures and to help reducing video pre-processing time before stored in database. Video indexes would be built automatically to support video browsing and full-content searching of lecture materials.

Introduction

Digital video is a growing domain and substantial efforts in researches have been made to exploit the richness of this medium [Grosky 94 and Flickner 95]. To make effective use of digital video in applications such as database systems and educational systems, it requires an effective way of understanding digital video. However, an ultimate algorithm for image understanding is still beyond the reach of current technology as described in [Flickner 95 and Nagasaka 94]. Full understanding of images to cover most application domains seems impossible and most results still require human adjustment. An easy way to assign content to video can be in form of inserting captioned text manually [Oomoto 93 and Petrakis 93]. Of course, the manual approach bears some limitations: firstly, the preprocessing task is very time-consuming; secondly, it depends on particular vocabulary used; thirdly, they do not allow queries based directly on visual and time-varying properties of the video content. Consequently, breakthrough in current image understanding technology is required to allow automatic image or video understanding. The following section gives some current examples in video applications research.

Related Researches

Digital video initially exists as an unstructured sequence of video frames and audio segments. For video retrieval purpose, the video sequences should be parsed into video shots, which could be defined as a sequence of frames without a scene change. A digital video model called algebraic video which allows expressing nested video structure and composition of video segments was described in [Weiss 95]. The system allows efficient access and composition of algebraic video. Owing to the variety of content in different video type, the parsing of raw video to algebraic video nodes in this system is still carried out manually.

Content parsing could be more effective when one has a prior model of a video’s structure. Such a model could apply to more structured video which owns a strong spatial order within the individual frames and/or a strong temporal order across a sequence of shots. News broadcasts has been selected as an application domain and has showed satisfactory result as described in [Zhang 95]. This automatic approach began with identifying key features such as the anchorperson of the a news video frame; then compares to domain models to identify objects; finally completed with identifying domain events as video shots [Oomoto 93]. The system developed allows automatic video parsing and indexing but still, video shots understanding requires the assistance of manual textual description to each video clip.
Objectives

In our research, we do not intend to design a sophisticated algorithm to understand the video. Rather, we have foreseen the digital video as a strong media in the education application domain, especially on the Computer Aided Instruction (CAI) systems. Traditionally, lectures could be recorded and stored in form of video tapes for self-learning purposes. Owing to the tape format, students could only access the video content sequentially. They do not allow non-sequential searching for the lectures. Digitizing and reorganizing the lecture video is a better way for constructing interactive learning system. Video understanding and indexing processes, however, are very difficult and time-consuming in most application. In our research, we have made use of the properties of lecture videos and have designed an fully-automatic methodology to digitize, storage and index these video materials. Here, we present a methodology for constructing systems for full-content retrieval of lecture videos.

Automatic Video Segmentation
Preparation and Digitizing

The current inexpensive and large-capacity storage media made it possible to digitize the mass volume of the analog video into digital format. The digitized video could be used to construct multimedia applications. In this domain, lecture video could be recorded in the lecture hall. To avoid excessive video processing time, lectures could be recorded in the simplest form without using any camera effect such as zoom and pan. The basic objects in the video view should contain the overhead screen and the lecturer. The spatial structure and the sample screen of a video lecture are shown in [Fig. 1a,b].

Figure 1: (a) spatial structure and (b) a sample screen of a lecture video

The lecture video would be undergone the digitizing process. To obtain best result, we should control the brightness and the contrast of the video so that the text on the overhead screen could be clear enough for character recognition.

Shot Partitioning

The primary task for constructing indexes for video is to break down the video stream into basic units. Each video shot would be then identified and indexed according to its content. The partitioning of video shot could be viewed as a process of detecting boundaries between consecutive shots. We have made an assumption that there should be significant differences between consecutive shots so that they could be separated sharply according to color, contrast, objects etc. In most application domain, detecting video boundary are not easy because there could be sophisticated effects such as zoom and pan within a video shot. Therefore, more structured videos such as news video is usually used for study. In this domain, the lecture video is even more structured compared with news videos. Each video shot in a lecture simply contains the content of one lecture slide. Unlike the news video, there could be no major camera effects such as cut, dissolve, wipe, fade-in, or fade-out in the video stream. The video boundary could be easily detected when there is a replacement of current lecture slide with next one on the screen.
Based on this belief, we have further defined an Area of Interest (AoI) on overhead screen in each frame image [see figure 1b]. Instead of examine every pixel in a frame, we would concentrate on the AoI. When there is a slide change, there should be a short period of blank screen in the AoI in the boundary frames. In comparing the pixel intensity histograms between consecutive frames in the AoI, video shot boundary could be determined directly [Zhang 95]. Once all video boundaries are detected, video shots for the whole lecture could be generally partitioned [see figure 2].

![Figure 2: video shots partitioning for a lecture video](image)

**Efficient Video Indexing and Searching**

Once the video shots are determined, the next task is to select an appropriate method for video shots indexing. Indexing of video shots requires understanding of video content.

**Content Extraction**

As stated before, automatic understanding of video is almost impossible in most domains using current technology. In this application domain, however, automatic extraction of video content is possible because we can make use of the lecture materials as shown on overhead screen. In other words, the content of each video shot is exactly the text content in each lecture slide. It is not necessary to assign keywords or passage to describe the video shot manually. Along the video shots, the AoI of each frame is the same. We could simply select the first frame (video boundary) as the Representation Frame (R-Frame) for that video shot [Zhang 95]. To obtain video content, we could apply Optical Character Recognition (OCR) routines to extract the video content. Based on the text extracted from the R-frame, we could build appropriate index for the video. Under this methodology, we have foreseen two potential problems in the processing: low accuracy and time consuming because of low resolution and quality of the original video. The dilemma is that the higher the resolution, the more storage space would be required. Thus, we have designed an more efficient approach for accurate indexing of lecture videos.

**Text-assisted Indexing**

The efficient approach would make use of the lecture text in the lecture. We have made an assumption that the lecturer could provide lecture slides in text format after the lecture has been presented. The lecture text source is divided slide by slide and is normally organized in same sequence as the lecture video. Theoretically, these lecture text is equivalent to video content extracted from AoI on the screen using OCR techniques. Instead of recognizing every characters on the screen, only the headings or subheading of the lecture slide on R-Frame are required to be identified. This heading could be used as the video index of that video shot. This video index would be used to match the slide heading in the lecture text source. Even the video index from OCR may not be totally accurate, we can still get a correct result using similarity match. Once the slide heading is determined, the rest of the lecture content could be obtained directly from the text source. In this way, the video content extraction process is made efficient by reducing the time spent on OCR. The video content is also accurate because they are obtained directly from lecture text source independent of the accuracy of the OCR process. After video indexes are identified for all video shot, they could be stored and used for constructing CAI systems.
Free Text Searching on Video Content

Our methodology has made possible automatic partitioning and indexing of lecture video. It also allows accurate and full content extraction for video shot. The video content could be stored and organized sequentially slide by slide in a data file. To allow free text searching on video content, we have built an inverted files which are indexes to the main slide file. It consists of an ordered list of each word or index term in the slide file. Associated with each index term are slide identifiers or slide headings, which in turn associated with video indexes [see figure 3]. In order words, once the appropriate indexed term is accessed, relevant video indexes could be retrieved that, in turn, lead to their appropriate video content.

There are two ways to demonstrate the usefulness of this methodology. Firstly, the learning environments for users to self-learn lecture materials becomes more effective. The student could access the lecture content accomplished with video explanations randomly. He could select appropriate lecture topics and associated video shot explaining that topic are shown on monitor. Secondly, this methodology allows fast video content browsing. Users could search a particular index terms such as “Education & Multimedia” a list of associated lecture slide and video shots are displayed. A video browser would display the results on the screen and users can then select the appropriate ones.

Problems and Enhancements

This efficient methodology is powerful especially on its ability to full-automatic shot partitioning and indexing of lecture or some other presentation videos. Practically, there are some issues to be considered. Firstly, a single video shot containing a single lecture slide could be detected as two or three video shots. This appears when the lecturer removes the lecture slide from the screen and do something and then replaces the same lecture slide again. Consequently, this breaks the continuity of the video shot and more than one video boundary would be detected. We have provided a solution for this kind of problems. When the system stores the video index, the system would automatically find out if there exists the same indexes appears in neighbor video shots. Video shots with the same indexes would be merged into a single video shot.

Secondly, our methodology is simply based on the detection of a short period of blank screens appeared on AoI between video shots when the lecturer replaces the slides manually. In normal case, a suitable threshold value would be set for this period. If the lecturer takes a few seconds $T$ to replace a lecture note page, the threshold value $T$ would also be set to detect the cut. In electronic presentation case, however, the new $T$ could be much smaller and is difficult to allow the detection of video boundary. Additionally, if special camera effects such as dissolve and wipe is used, an enhanced algorithm to detect video boundary is required. The enhanced algorithm could increase the complexity in video partitioning process.
Conclusions

We have designed a methodology for automatic video partitioning and indexing of lecture video for CAI systems. The methodology allows automatic selection of R-frame for each video shot. With the aid of lecture text, video content could be extracted more accurately and efficiently. By constructing full text index, user could retrieve and browse the lecture video content randomly according to user criteria. Future research such as hierarchical video indexing and audio segmentation would be outlined to improve this methodology and the usefulness of the systems built.

Reference

Abstract: This paper focuses on development of the Computer Logging of User Commentary (CLUC) method for evaluating computer network-assisted distance learning. The method was developed at National Chiao Tung University in Taiwan. CLUC is an innovative evaluation method that combines computer logging techniques and self-reporting methods used widely in the field of formative evaluation. The components and use of CLUC are reported. Related research issues are also addressed.

Introduction

Formative evaluation is one of the most critical steps in the development of learning materials. The field of formative evaluation is still in its infancy in computer network-assisted distance learning. The search for creative and effective methods for conducting formative evaluation on such a complicated technology-dependent learning system represents a challenge for formative evaluators and system designers. The innovative ideas presented in this paper are some first steps toward addressing this challenge.

The goal of this paper is to present a computer logging method called CLUC (Computer Logging of User Commentary) that collects user-reported inputs. The paper first presents two computer-logging and user-reporting evaluation methods, and then proposes the new evaluation method, CLUC, along with some sample screens from it. The final part of the paper outlines the use and research issues involved in the CLUC study.

Review of Formative Evaluation Methods

Computer logging has been used in evaluating user-interface designs for a long time [e.g., Bradford et al. 1990; Nielsen 1993]. In computer-assisted instruction, computer logging is sometimes used for formative evaluation under the name of mediated evaluation techniques or computerized data collection [Flagg 1990]. The basic idea of logging is to have the computer automatically collect statistics on detailed use of the system. The major advantages of logging are that it automatically and continuously collects objective data for further analysis and interpretation, and does not interfere with users during their interactions with the system. Through the use of computer networks, the logging method can be used to collect data from large numbers of users working under vastly differing circumstances.

Self-reporting, or querying, represents a group of evaluatory techniques such as think-aloud, survey, interview, open-ended questionnaire [Dix et al. 1993]. The major advantage of self-reporting is that it directly collects first-hand feedback from users. Depending on the methods used, quantitative data (such as from surveys) and qualitative data (such as from interviews and open-ended questionnaires) can be obtained for further analysis and interpretation. The disadvantages, however, are that some methods, like think-aloud intrude on users' interactions with the system, and some post-hoc methods such as interviews and open-ended questionnaires may not collect valid data due to the administrative methodology (e.g., poor interview techniques or questionnaire design).

Comparing these two methods -- computer logging and self-reporting -- it is found that the basic differences between them is in the type of data collected -- objective vs. subjective -- the way of collecting and logging data -- automatically vs. manually -- the degree of computer involvement in the collecting and storing of data -- entirely computer-dependent vs. (not necessarily) partially computer-dependent -- and the level of interference implied -- intrusive vs. non-intrusive. These differentiations help us clarify the methods in terms of their natures.
and (dis)advantages. Depending on the users, tasks, and situations being evaluated, appropriate evaluation method(s) can be chosen based on the differences outlined above.

The CLUC Method

The proposed CLUC method can be considered a hybrid that uses computer logging techniques to collect commentary during users' interactions with the learning materials presented in a computer network-assisted distance learning system. CLUC is designed to be used to collect inputs from large numbers of users working in different locations. The inputs are automatically stored, calculated, and then presented in a format that can be easily interpreted by formative evaluators and system designers. The basic idea came from the author's experience of conducting a formative evaluation of a networked hypertext learning system. This system provided a course on Basic Computer Concepts (BCC) consisting of more than 100 instructional nodes. Difficulties in collecting students' comments on particular parts of the course content were encountered. For example, several students indicated in their open-ended questionnaires that more definitions for some terms were needed. When we evaluators interviewed them to find out which terms they meant and where the terms were, the students had difficulty in finding the terms in the morass of course information. We therefore saw the need for a new logging mechanism that allows students to mark contents they think should be revised, and that saves a lot of human-evaluator's recording work during the learning process.

The resulting CLUC method consists of 3 major components on the user-interface:

1. buttons that allow students to activate input windows;
2. pop-up windows that present multiple-choice with blank space to allow students to input opinions; and
3. evaluator's windows for viewing statistical results of student inputs.

Buttons

The button allows students to activate pop-up input windows. Granularity is the major design consideration, that is, how often the buttons appear in one learning node. In the prototype version of CLUC, the button was placed at the end of each paragraph, as shown in [Figure 1], given the assumption that each paragraph presents only one concept or a part of a concept. Having the button appear at the end of each sentence would render the text layout of a node very different from a "normal" text page, and this "unnaturalness" may have drawn much of the students' attention away from the content. On the other hand, having the button appear only at the end of each node would make it difficult to identify the specific part of that node students had opinions or questions about.

Pop-up Windows

After a student clicked the button at the end of a paragraph, a pop-up window appeared on the screen, and the at the end of the chosen paragraph remained highlighted. The pop-up window was designed to collect students' opinions on that specific paragraph [Figure 2]. The window was small enough to allow the content presentation on the screen to be visible, and large enough to present the multiple choices and allow space for open-ended comments.

In the pop-up window, a multiple-choice display is shown, along with a space for student to enter comments. The stem of the item is "Enter your choices." The choices were:

- more explanation
- need definition
- need examples
- need pictures and graphics
- other ________________
Students were allowed to enter as many choices as they desired for that unit. The first 4 choices -- need more explanation, definition, examples, and pictures/graphics -- were drawn from the author's experience of evaluating the BCC course in the hypertext distance-learning system mentioned above. These 4 choices were major obstacles to student understanding of the content, as reported in their surveys, open-ended questionnaires, and interviews. The fifth choice, other, was followed by a blank space to collect students' opinions not covered in the first 4 choices. Students can type in up to 10 lines, and use a scroll bar to adjust the presentation of the window. [Figure 2] shows a multiple-choice pop-up window.
Evaluator's Windows

The evaluator's course presentation screens [Figure 3] are basically the same as those seen by students. However, when evaluators click the button at the end of each paragraph, a CLUC evaluator's window shows up. This window displays student input statistics. The right-hand part of Figure 3 presents an evaluator's window. In this window, the first line presents the statistical data that 16 out of a total of 42 students participating in the formative evaluation input opinions on this particular paragraph. The 4 lines below that present the choice frequency. For example, 8 of 16 students (50%) chose more explanation, 12 of 16 students (75%) chose need definition, and 0 chose need examples or need graphics or pictures. One student (6%) wrote "I don't know what the PDE is, please define..." The evaluator's window helps identify the problematic parts that students think need revision.

![Figure 3: A course presentation screen with the CLUC evaluator's window open](image)

The Use of CLUC Method

The CLUC method was implemented on the CORAL (Cooperative Remotely Accessible Learning) system. As its name implies, CORAL is a network-based computer assisted learning (CAL) system that supports cooperative distance learning. It is under development at National Chiao Tung University (NCTU) in northern Taiwan. The CORAL system is built on the Internet by employing a Netscape-like browser with enhanced instructional functions. For more details in the functions and architecture of CORAL, please refer to [Tsai et al. in press].

A total of 42 students and 2 evaluators participated in trying out the prototype CLUC method. CLUC was applied to 10 instructional nodes in the CORAL course -- An Introduction to Computer Networks. The goal was to evaluate the feasibility and the usability of the method, rather than to collect student opinions for course content revisions. However, evaluators in this tryout collected useful evaluation results which could eventually be used for modification of the course content.

Students participating the formative evaluation were first welcomed, and informed of the purpose of the evaluation. The CLUC method was then introduced, including the buttons students would encounter while reading through the content, and the following pop-up windows with the multiple-choice items. The evaluator explained that help would only be provided for the use of the CLUC method, but not for the course content during the evaluation.

Selected students were observed during and interviewed after their learning experience. Indications were that they found CLUC not difficult to use once they had tried it a few times. However, some usability problems were
discovered. For example, some students were unaware they had to close the CLUC pop-up window when they were finished with it, and some did not know the window could be moved.

Students were interviewed afterwards and asked whether CLUC and the button interfered with their progress through the course content. Most of the students said that the button was not very intrusive and that the pop-up window was not big enough to block the textual information. However, some students indicated that they paid more attention to problems with the content presentation because CLUC was there, and that the purpose of their encounter with the course was influenced accordingly.

Future Research Issues and Conclusion

Trying out the CLUC prototype has raised several research issues. First, the CLUC user-interface could be improved. For example, a close button should be provided so students can click to close the pop-up windows. This is particularly useful for students unfamiliar with the Microsoft Windows practice of clicking the square in the upper-left corner of a window and choosing "Exit" to close it or double-clicking the same square.

Secondly, since CLUC was designed as only one evaluation method for networked CAL course content, it has been suggested that a test on the content be conducted after students complete their learning experience. In CLUC, the unit of course content being evaluated is paragraphs in instructional nodes. Understanding of the whole node and the whole course, however, was not evaluated. [Reiser & Kegelmann 1994] stated that the evaluation of instructional software is incomplete without a report on student learning performance. Therefore, an embedded test for the node, and a post-test for the whole course, as conventionally used in formative evaluation, are recommended to evaluate students' learning achievements.

Related is the issue of whether the use of CLUC interferes with students' learning achievement because of its embedded distractions during their learning process. As mentioned above, CLUC is a hybrid method of using computer logging to collect student commentary. It falls in between its precursors, self-reporting and computer logging, on the intrusiveness -- non-intrusiveness continuum, and in the degree of subjective vs. objective data it yields. Understanding the nature of the CLUC method and its inherent advantages and disadvantages will help us to make better decisions on how to use CLUC.

The reports CLUC generates for evaluators can be enhanced in terms of their statistics and presentations. For example, in the prototype CLUC, evaluators only received statistics on each choice students made for a particular paragraph in one instructional node. Statistics on choices for the whole node and the whole course, and from each student were not available. If available, research studies such as the correlation between the entry numbers of students and their learning achievements can more easily be obtained.

Most important, the validity and reliability of CLUC should be explored. Validity refers to the appropriateness of the measurement, that is, whether CLUC in fact measures what it is designed to measure. Reliability refers how reliable or stable the measured data is. In order to establish CLUC validity and reliability, the author plans to conduct a second trial. A test-retest (use-reuse) method will be conducted to measure the stability of the CLUC method, and the correlation between CLUC inputs and learning achievement will be investigated to establish the concurrent evidence of validity.

The CLUC method described in this paper is an innovative approach to formative evaluation of the courseware content in computer-networked distance-learning situations. It combines the existing computer logging and widely-used self-reporting methods. It saves labor-extensive evaluation work during the learning process. It can be used as a supplement to traditional embedded test and post-test methods for evaluating learning materials. It is expected that more research will be conducted on formative evaluation, and more methods such as CLUC will be developed so that more computer network-assisted distance learning materials can be effectively evaluated, and hence, more students can benefit from these better learning materials.
References


Abstract: This paper is an evaluation of a hypermedia music CAL system based on the results of an experiment conducted in an elementary school. A total of sixty sixth-grade students participated in the study. Sixteen students were randomly assigned to the experimental condition and the rest were assigned to the control condition. An attitudinal questionnaire and a system evaluation questionnaire were given to the students at the end of experiment. The results show that subjects in both groups performed insignificantly in the post-test. Previous music or computer experience did not affect learning performance in either group. Interaction effects on treatment by gender were found in post-test scores, boys benefited more from the CAL system than girls did. Plausible explanations, and implications for future study are provided at the end of this paper.

Introduction

During the past decade the swift advances in video technology and computer technology have created a new dynamic educational medium: multimedia, for both educators and practitioners. Apple Computer Inc. (1991) states that "interactive multimedia implies multiple forms of communications media, controlled, coordinated and integrated by the microcomputer." As personal computers become faster, more powerful and cheaper, while at the same time offering higher-quality visual and audio output, multimedia becomes a more pragmatic educational option.

A multimedia system combined with a hypertext model is called a hypermedia system. In such a system, information is organized in a "link-node" based model and can be non-linearly presented. The relationships among nodes are prescribed by "link". The hypermedia system has a great potential in the future if networked with large multimedia database systems to support versatile applications. By offering versatile information resources and by being integrated by desk-top personal computers, the hypermedia CAL systems are able to facilitate the dialogue between learner and educator. In the present study, a hypermedia music computer assisted learning (CAL) system using the "DIRECTOR" authoring tool in Macintosh platform will be evaluated.

System Structure

The instructional material included in the system is centered on the second movement of the Czechoslovakian musician, Dvorák's, symphony No. 9 in E minor "From the New World", which was adapted for a learning unit in the sixth-grade's music textbook. The structure for the entire system is shown in Figure 1.
Music Form Introduction. This section contains two parts: an analysis of three units of music form and an appreciation of songs with the same music form. The three units of music form are "motive", "repetition", and "sequence".

Introduction of Symphony Organization. The first part of this section introduces four categories of musical instruments used in the symphony: "string instruments", "wind instrument", "brass instruments", and "percussion instruments". The second part introduces basic conducting techniques.

Introduction of the Composer. Six sub-sections included in this learning unit are: "composer's hometown and family life", "academic & professional performance", "biography", "list of composition", "composition appreciation", and "contribution".

Pre-test. The pre-test is used to identify learners' entry knowledge levels. The test consists of ten items covering three major learning sections.

Mastery Test. The last section of the system is a "mastery test". The test contains thirty test items from three learning sections, including the ten test items from the pre-test.

Research Methods

Subjects

A total of sixty sixth-grade students from five classes at an elementary school in Chungli, Taiwan, participated in the study. The target students were selected as follows: each sample class was divided into three groups on the basis of the music teachers' rankings (i.e., upper, middle, or lower third); four students, two boys and two girls, were chosen from each of the groups. Due to the limited number of computers available, only sixteen students were randomly assigned to experiment treatment.

Procedure

Students in both treatment groups participated in a forty-minute instructional unit either in the traditional lecture type or in the hypermedia CAL form. An attitudinal survey and a system evaluation questionnaire were given to the students at the end of the instruction. A pre-test and a post-test were given prior to and after the experiment for both groups.

Experiment Group. Sixteen subjects with equal gender distribution participated in the experiment. The experiment lasted for about forty minutes. A two-minute introduction about the purpose of the study and the procedural outline of the experiment was given prior to each run.

Control Group. Subjects learned the same instructional material as the experiment group via classroom lecture by a music teacher. Two assistants were assigned to observe and record classroom dynamics.

Instruments

A self-report questionnaire was sent to all subjects at the end of instruction and a system evaluation survey was distributed to the experiment group students after completing the experiment. It was of interest to test if gender difference exists in both learning performance and attitude towards music learning. The system evaluation survey was designed to ask for learners' feedback about the hypermedia music CAL system. Data collected from the experiment were analyzed using statistical techniques such as two-way ANOVA, and t-test. Seven variables investigated in the survey were:

Gender. This variable is used to determine if gender differences exist in music learning performance.

Grades. This variable, obtained from the music teacher, regards the student's overall performance of the last semester.

Pre-test. This variable was obtained from students' performance on the pre-test. The pre-test is for identifying learners' entry knowledge level before learning.
Mastery test (post-test). This variable was obtained from students' performance on the mastery test held at the end of instruction. The mastery test is a summary test for the entire instructional material.

Familiarity. This variable considers the subject's previous computer experience.

Curricular. This numeric variable describes how many hours the subject spends on extra-curricular music-related activities.

Evaluation. This is a composite score of the mean of 21 Likert scale items. This variable is used to evaluate the system's effectiveness and suitability.

Hypotheses to be Tested

The above variables are included to test the following hypotheses:

H0(1): m_experiment = m_control for pre-test, mastery test, and grade.
H0(2): m_male = m_female for pre-test, mastery test within both groups.
H0(3): m_computer = m_non-computer for pre-test, mastery test, attitude toward music learning, and grade within both groups.
H0(4): m_curricular = m_non-curricular for pre-test, mastery test, attitude toward music learning, and grade within both groups.

Selected Findings

Table 1 provides information about treatment group means, gender means within treatment and in overall. Due to the unbalanced number of subjects in the two groups, limited sample size in the experiment group and in the test items, findings should be interpreted with caution. The descriptive statistics show that girl students had higher grades and performed better than the boys on the pre-test and the post-test. It can also be found that students in the experiment group learned more than those in the control group. However, students in the control group, even those with lower grades, had a better performance on the pre-test and the post-test than those in the experiment group.

Table 1. The Score Means in Treatment Groups and in Overall.

<table>
<thead>
<tr>
<th>Grades*</th>
<th>Control Boy/Girl Ave.</th>
<th>Experiment Boy/Girl Ave.</th>
<th>Overall Boy/Girl Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades*</td>
<td>2.73/2.86</td>
<td>2.79</td>
<td>1.75/1.13</td>
</tr>
<tr>
<td>Pre-test</td>
<td>4.82/4.76</td>
<td>4.79</td>
<td>3.38/4.63</td>
</tr>
<tr>
<td>Post-test</td>
<td>7.23/7.24</td>
<td>7.23</td>
<td>7.00/7.38</td>
</tr>
<tr>
<td>Post. - Pre.</td>
<td>2.41/2.48</td>
<td>2.44</td>
<td>3.63/2.75</td>
</tr>
</tbody>
</table>

*: Higher scores represent lower achievement.

Treatment Effects

From Table 2 and 3 it is found that the first hypothesis that there are no treatment effects on the mastery test can not be rejected. In other words, both boys and girls in the control group performed as well as their partners in the experiment group. A closer examination of the significant differences in the pre-test scores indicates that students in the control group, especially boys, came with much better prior knowledge than those in the experiment group. This may suggest that students in the experiment group learned better than those in the control group. In other words, although the treatment effects on the post-test scores were not found, the CAL system did impressively enhance the experiment group's students performance by improving the experiment group's poor performance on the pre-test scores. This is verified by the significant post-test and pre-test differences found for boys and for overall.

Table 2. Mean Differences, t-values & P Values in Gender Groups.
Grades: 0.977 2.219 0.035** 1.732 4.294 <.001**
Pre-test: 1.443 2.257 0.032** 0.137 0.243 0.810
Post-test: 0.227 0.450 0.656 -0.137 -0.325 0.747
Post. - Pre.: -1.216 -2.489 0.019** -0.274 -0.472 0.641

**: The P values is significant at 0.05 level, *: the P value is significant at 0.1 level.

Table 3. Mean Differences, t-values & P Values in Treatment Groups.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th></th>
<th>Experiment</th>
<th></th>
<th>Overall: t-value (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B/Girl</td>
<td>t-value</td>
<td>P</td>
<td>B/Girl</td>
<td>t-value</td>
</tr>
<tr>
<td>Grades</td>
<td>-0.13</td>
<td>-0.39</td>
<td>0.70</td>
<td>0.625</td>
<td>1.616</td>
</tr>
<tr>
<td>Pre-test</td>
<td>0.056</td>
<td>0.12</td>
<td>0.91</td>
<td>-1.25</td>
<td>-2.105</td>
</tr>
<tr>
<td>Post-test</td>
<td>-0.01</td>
<td>-0.03</td>
<td>0.97</td>
<td>-0.38</td>
<td>-0.629</td>
</tr>
<tr>
<td>Post. - Pre.</td>
<td>-0.067</td>
<td>-0.18</td>
<td>0.86</td>
<td>0.875</td>
<td>1.208</td>
</tr>
</tbody>
</table>

**: The P values is significant at 0.05 level, *: the P value is significant at 0.1 level.

Gender Differences

It can be found from Table 3 that in the experiment group, the girls had significantly higher scores on the pre-test than the boys did. This score-difference, however, did not reappear on the post-test scores which may imply that boys benefited more than girls from the CAL system. On the other hand, girls in the control group obtained lower pre-test scores but performed better in the post-test than boys, which may imply that girls had better performance than boys in the traditional lecture classroom.

Treatment by Gender Interaction

Although gender difference was not significant within/across treatment in post-test scores, it was found that girls, overall, performed better than boys did on the three tests. A noticeable gender * treatment interaction effect was also found. From Figure 3 an interesting trend reveals that girls outperformed in the experiment group (7.38 vs. 7.24) whereas boys did better in the control group (7.23 vs. 7.00), although both differences are not significant. In addition, it is found that girls in the experiment group had lower pre-test scores than girls in the control group (4.63 vs. 4.79), but performed better on the post-test than girls in the control group (7.38 vs. 7.23). Since the test size is quite limited, no further comments can be made here.

Both boys and girls in the experiment group obtained significant post-test/pre-test differences than those in the control group (3.63, 2.41 vs 2.75, 2.44). The differences for boys are much higher than for boys which may imply that boys benefited more from the CAL system than girls did.

Figure 2. Interaction Line Plot for Pre-test
ANOVA techniques were employed to examine possible treatment by gender interaction effects in grades, pre-test, and post-test scores. It can be found from Table 4 that there exists larger treatment differences in grade and pre-test scores than in post-test scores which indicates the non-neglectable sampling errors. Although not significant, one interesting finding mentioned earlier are the interaction effects which are worth further study.

Table 4. ANOVA Table for Grade, Pre-test, and Post-test Scores.

<table>
<thead>
<tr>
<th>Factor</th>
<th>df</th>
<th>Sum of Square</th>
<th>Mean of Square</th>
<th>F Ratio</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>21.398</td>
<td>21.398</td>
<td>20.917</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>0.715</td>
<td>0.715</td>
<td>0.699</td>
<td>0.4112</td>
</tr>
<tr>
<td>Treatment*Gender</td>
<td>1</td>
<td>1.661</td>
<td>1.661</td>
<td>1.624</td>
<td>0.2121</td>
</tr>
<tr>
<td>Residual</td>
<td>56</td>
<td>57.310</td>
<td>1.023</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>1</td>
<td>7.277</td>
<td>7.277</td>
<td>3.488</td>
<td>0.0696</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>4.154</td>
<td>4.154</td>
<td>1.991</td>
<td>0.1676</td>
</tr>
<tr>
<td>Treatment*Gender</td>
<td>1</td>
<td>4.974</td>
<td>4.974</td>
<td>2.384</td>
<td>0.1317</td>
</tr>
<tr>
<td>Residual</td>
<td>56</td>
<td>116.834</td>
<td>2.086</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>1</td>
<td>0.024</td>
<td>0.024</td>
<td>0.193</td>
<td>0.8914</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>0.434</td>
<td>0.434</td>
<td>0.349</td>
<td>0.5604</td>
</tr>
<tr>
<td>Treatment*Gender</td>
<td>1</td>
<td>0.387</td>
<td>0.387</td>
<td>0.312</td>
<td>0.5826</td>
</tr>
<tr>
<td>Residual</td>
<td>56</td>
<td>69.548</td>
<td>1.242</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: the first block is for grade, the second is for pre-test, and the third is for post-test.

Conclusion and Implementation

Although treatment effects on the post-test score were not found, the CAL system did impressively enhance the experiment group's performance by improving the experiment group's poor performance on the pre-test. Plausible reasons for the insignificant treatment effects may be that (1) the limited test items and instructional material makes carry-over effects, and (2) the low difficulty level of the instructional material results in ceiling effects in both group. The gender * treatment interaction effects should be noted. In overall, girls learned better than boys did but boys benefited more from the hypermedia music CAL system than girls did. Due to the limited sample size, this conclusion is made with caution. This interesting gender * treatment effect is worth further study.

In order to investigate possible effects on gender * treatment interaction, a further in depth study is suggested. Due to the environmental and equipment constraints, the experimental group was much smaller than the control group; the fewer number of subjects in the experiment group may have resulted in the magnified treatment effects on the grades and the pre-test.

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Abstract: The purpose of Project Footsteps is to promote collaboration and cross-cultural understanding among secondary teachers and students across geographical distances using distance learning and multimedia technologies. In this project, multimedia and distance technologies mediate personal growth exploration and the sharing of personal identities among young adolescents across sites. Students use distance technologies for collaborative exploration of ideas, and they develop multimedia presentations that they share across distances.

Project Footsteps provides students and teachers opportunities for experiences beyond their immediate social and geographic communities. Students enjoy project activities and participate with enthusiasm. Students develop their reading, writing, and visualization skills through electronic mail communication and the development of multimedia projects. They express themselves through the visual arts of multimedia. Furthermore, they develop poise and interpersonal communication skills through interactive video conferencing. They learn about themselves and their cultures through sharing with others across distances. They learn about others as they explore differences and common ground. Finally, they grow in their moral development and critical thinking as they discuss issues of importance to them.
The initial pilot project involves Berta Cabaza Middle School in San Benito, Texas, which is located in the Lower Rio Grande Valley and Jones Intermediate School in Waller, Texas, which is located about 350 miles to the north of San Benito. Student populations in these schools are racially and culturally diverse and students participating in the pilot equitably represent the student populations. The Academic Excellence Indicator System (AEIS) indicates that 96.3% of students in San Benito are Hispanic, and 80.8% are economically disadvantaged. According to the AEIS report, 46.6% of students mastered reading, 50% mastered writing, 28.5% mastered math, and 25.3% mastered all tests. The greatest area of weakness is mathematics; but improvement is needed in reading and writing as well. The Academic Excellence Indicator System (AEIS) indicates that 40% of students in Jones Intermediate are Anglo, 30% are Hispanic, and 30% are African American. Thirty-nine percent of students are economically disadvantaged.

Higher education partners participating in this project are Texas A&M University, the University of Texas at Brownsville, and Prairie A&M University. In addition to Berta Cabaza Middle School and Jones Intermediate, school partners include A&M Consolidated High School in College Station, Bryan High School in Bryan, Somerville Junior High and High Schools in Somerville, and Furr High School in Houston. As we assess and refine the project, we will expand to include other schools in Texas, other states, and other nations. For example, expansion plans beyond Texas include Hatch Valley High School in Hatch, New Mexico.

Perspective

The idea underlying this project is neither complicated nor new. By collaborating across distances students from different locations can help each other learn (see Yi & Majima 1993; McMann 1994). Students learn from one another by sharing experiences and ideas about issues of importance to them. We base our project on the perspective that the experiences and ideas of all students can be used as a foundation for learning. Three philosophical and theoretical assumptions undergird this project: 1) transformative pedagogy can foster personal growth, 2) collaborative learning experiences can foster critical inquiry, and 3) technology can foster collaborative learning.

Transformative pedagogy suggests that the role of education is to promote personal growth of individuals. Social responsibility and productive employment depend on the maturation and self-actualization of individuals (see Maslow 1973). When adolescents are given the opportunity to describe to their peers their home life, their goals, their thoughts and values, their likes and abilities, and their stories, they are forced to critically reflect upon their understanding of their experiences in a social context beyond their immediate community. In The Universal Schoolhouse, James Moffett (1994) calls for focusing on individual, personal development in education. In addition, he claims that unresolved societal problems that stem from prejudice and inequalities can be solved by sharing individual understanding of experience:

Public education has to enable learners to entertain diverse points of view and to enrich their experience well beyond familial upbringing. Intermixing the learners themselves—of all ages and backgrounds—helps do this very effectively. Spiritual education...depends on widening identity (p. 72).

To be spiritual is to perceive our oneness with everybody and everything and to act on this perception. It is to be whole within oneself and with the world. Morality ensues (pix). In the interest of democracy, schools must become places that cultivate caring, tolerance, and respect for self and others. Henry Louis Gates (1994), the noted African American author and literary critic, states that "Any human being sufficiently motivated can fully possess another culture, no matter how 'alien' it may appear to be.... But there is no tolerance without respect--and no respect without knowledge." Individuals grow and learn tolerance and respect for others by creating and by exchanging ideas about what they create. In addition, creative work facilitates personal healing and growth (see Moffett 1994).

In order for students to transform into more tolerant and respectful citizens, they need to develop relationships with people from diverse cultures and backgrounds. Collaboration provides for relationship-building. Furthermore, a growing body of literature recommends collaboration among schools, universities, and communities in order to reduce discontinuities among the different continuity groups (see Goodlad 1990; Holmes Group 1986). In her study of a school-university collaboration, Metcalf (1994) found that the collaborative learning process moves from primarily one-way interactions to increasingly reciprocal interactions in a dynamic growth process towards an increasingly complex network of relationships. The collaborative learning process has the potential, then, to transform individual participants from parochial to global perspectives.

Our increasingly diverse society challenges teacher educators to prepare teachers to meet diverse needs in an increasingly technological society (see Banks & Banks 1992; Hilliard 1992). In response to this challenge, we are using the power of multimedia and distance technologies to motivate ethnically diverse and geographically separated students to write about and share with each other who they are. Multimedia software has an advantage over pencil and paper in that students can easily include visual representations of themselves, their interests, and their beliefs. In addition, with the scrolling text option in HyperStudio, the multimedia software that students will use, students can write volumes about themselves. Multimedia files can be shared with others by being put on disks and sent through
the mail, or via File Transfer Protocol or the World Wide Web. Presentations can be projected before a class, viewed individually, and/or viewed in small groups. Files can be stored by students as they get ideas and receive feedback from each other. In addition, and perhaps most importantly, multimedia software files are easily edited and revised so that students can change their presentations as they grow and change.

Several studies and theoretical expositions have discussed the power to learn through writing (see Helmers 1994; Zinsser 1988). Other studies have investigated the use of multimedia software across the curriculum and indicate that students learn by developing multimedia projects (see Benafel 1993; Hay 1994; Wilhelm 1995).

Distance technologies facilitate meetings between students from different cultures or backgrounds. They also help students to reanalyze their own worlds and enhance their understanding of their own lives based upon feedback that students get from each other. Telecommunications technologies have the potential to equalize education so that "all children gain access to the communication tools that are essential for genuine democratic participation" (see Cummins & Sayers 1995). They bring educational opportunities to children who would otherwise be disadvantaged due to economic, physical, or geographic limitations. Many students in participating schools are isolated from communities beyond their own neighborhoods. The technologies reduce isolation, and in addition they broaden the experiences of advantaged students by giving them opportunities to learn the perspectives of diverse learners.

In Project Footsteps, participating teachers and students are being given an opportunity to explore serious issues through meaningful application of technology while exploring personal identity and identity development. Student development of multimedia presentations for self-actualization and enhancement of communication allows teachers and students to embrace diversity in an ever-changing society within and across classroom settings. The implications of this project are vast. As students are afforded an opportunity to develop more sophisticated technological skills, they are also afforded the opportunity to share perspectives with peers across sites. They develop through expressing their own voices and listening to the diverse voices of others. Teachers are able to facilitate and assess the development of their students’ voices and the impact of technology to promote understanding.

Methods

Educators from three universities and three schools meet via three-way video conferences to share and plan the collaborative project. The school and university partners are equipped with interactive compressed video systems through grants from the Texas Education Agency, and they have Internet connections as well.

Implementation of the Project

In the implementation phase we are guiding students and teachers to technological competence in HyperStudio. Students are advised to design cards on paper before working on the computer. They then create presentations of themselves in HyperStudio. The first card in their stacks includes a menu linked to creative work that students complete regarding the categories: home, likes and abilities, thoughts and values, goals, and stories. Students share presentations within and across settings. Then they share responses to each others’ presentations within and across settings. After students receive feedback, teachers give students opportunities to revise and amplify their presentations and share them with students at the distant locations so that they can concretely demonstrate change and growth.

We brainstorm to identify sources for activities that might elicit from students multimedia production that will increase their self-awareness. A sample of students in the schools from general education and special populations are currently working with us brainstorming, developing and identifying activities that appeal to our intended project participants. Initially students develop simple personality profiles, perhaps including physical description, family, favorite setting, tastes, or habits. Then students develop hyperstudio cards that inspire deeper self-inspection. For instance, the cards might describe: ancestry, people one admires, culture of family, favorite movie and why, or a description of a perfect day. Students can explore their personal goals by presenting who they want to become. For instance, cards might describe: what they will be doing when they are 18, 25, 30 and each decade following, what kind of family they want, and what the perfect career for them might be. Students clarify their values by visually presenting solutions to values clarification exercises. They respond to provocative stimuli such the video, "Prejudice: Answering Children's Questions" (see Roddy 1992). Following group discussion, they describe themselves and their feelings and thoughts about significant personal and societal issues such as prejudice.

In the participating schools, activities are being implemented in sixth grade advisory classes where affective objectives were targeted. Self-esteem activities from the "I Can" curriculum are translated into lessons that require responses on HyperStudio screens (see Ziglar 1989). In addition, teachers use inspirational books such as "Chicken Soup for the Soul" to motivate students to explore their values and visualize them on multimedia (see Canfield & Hansen 1991). Students also have e-mail pals whose descriptions they include in their presentations. They compare
and contrast themselves to their pals after being encouraged to ask and answer probing questions which inspire multimedia visualization.

Results and Educational Importance

Researchers are coming together from distant locations in Texas to explore educational practices associated with multimedia development and formation and sharing of personal identity. Participating inservice teachers are being given a meaningful application of technology in their classrooms and opportunities to collaborate. Students are being given the tools to explore and present who they are to a broad audience. They have the opportunity to respond to others' presentations and to get feedback from others about their presentations. We have discovered that when public school students are given an activity that leads them to explore their identities, they will work for hours with PowerPoint or HyperStudio to express their understandings.

The results of this project will have both theoretical and practical significance. Theoretical significance includes contributions to the development of theory about collaborative learning, distance learning, attitudes toward technology and multimedia development. Practical significance includes contributions to the literature about school-university collaboration, and the effectiveness of distance learning and multimedia technologies in helping young adolescents make sense of their experiences and promoting cross cultural understanding.

References

Abstract: This study investigated the relationship between student learning style, use of the computer as a cognitive tool, and the social context in which learning occurs. The subjects were 15 gifted freshmen who had been accepted into a magnet high school that fosters a unique, technology-rich environment dedicated to a constructivist, team-oriented approach. The subjects were given Dunn and Dunn’s Learning Style Inventory and a questionnaire before and after the school year. Results show that at the end of the year student learning style was affected by the social context. There appears to be a relationship between learning style, social context, and technology. This study also found that after one year some students displayed low preference for learning in this environment. This paper concludes that the social context must encourage many different forms of learning styles.

The purpose of this paper is to document, explore and explain a pilot research project that was undertaken in the 1994-95 school year to investigate the relationship of student learning style and ability to use the computer as a cognitive tool. The primary objectives of this study were: 1) to explore whether learning style impacted how gifted students used computers as a vehicle for deeper understanding into a subject area; 2) to investigate whether or not learning style would change after a year of schooling in a unique, technology-rich, educational environment dedicated to a constructivist, team-oriented approach to learning; 3) to analyze the study’s research questions and methodology, pinpointing revisions that would need to be addressed in a more comprehensive study.

The study was small in scope, involving a team of 15 freshmen from all over Bergen County, New Jersey who had been accepted into a “magnet” high school that emphasizes science, mathematics and technology. The high school was conceived in 1990, has approximately 50 students per grade, and as of 1994-95 school year, did not have a graduating class yet. The school, The Academy for the Advancement of Science and Technology, is dedicated to a constructivist approach to education and encourages teachers to keep teacher-directed lectures to a minimum. Technology is infused into all classes and every student and teacher is given a computer to take home. The use of multimedia projects to present projects is heavily emphasized. This environment fosters a unique approach to education and is very supportive of research being conducted on its premises. Within such a rich context, a small, exploratory pilot study seemed appropriate for the first year of research. Here, initial research questions could be tested to assess their validity, and instrumentation and methodology could be tried out on a small number of students.

Background

This study was based upon the theoretical assumption that the most effective use of technology in the classroom is when it is used as a cognitive tool by students. When students use technology as a new “literacy” tool, they must apply problem solving processes and employ higher order reasoning strategies leading to cognitive growth. As such, the technology becomes a “mind-extension ‘cognitive tool’.” (Derry & Lajoie 1993, p.5) When students use technology as a literacy tool, the way the students learn changes, thus having a direct positive impact upon student achievement (Cohen 1995).

By focusing on learning styles, this project attempted to use two different theoretical models to test learning style-- Dunn and Dunn’s Learning Style Inventory (LSI) (Dunn, Dunn & Price 1989) and Gardner’s Theory of Multiple Intelligences (1983). A more complete profile of each student would emerge by using a statistically valid and reliable test such as the LSI and also administering a self-made questionnaire to assess the seven multiple intelligences that Gardner proposes.

Dunn and Dunn state that a learning style is a biologically and developmentally imposed set of personal characteristics that make the same teaching method effective for some and ineffective for others (Dunn, Beaudry
Their instrument for measuring learning style, Learning Style Inventory, obtains a profile of each student in four major areas: 1) environment including sound, temperature, light, and design; 2) emotionality including motivation, responsibility, persistence, and the need for either structure or flexibility; 3) sociological needs including learning alone, with peers, with adults and/or in several ways; and 4) physical needs including perceptual preferences (auditory, visual, tactile and kinesthetic), time of day one prefers to study, intake and mobility. This inventory results in an individual profile of a student’s preference toward learning. Dunn and Dunn feel that classrooms need to concentrate more upon individual learning style because students tend to learn and remember better and enjoy learning more when they are taught through their learning style preferences (Dunn 1990).

From a different theoretical perspective, Gardner developed his Multiple Intelligence Theory based on the notion that intelligence can be viewed in terms of human potential and that it needed to be broadened beyond the scope of the IQ score. He defined seven forms of intelligence: linguistic (the capacity to use words effectively), logical-mathematical (the capacity to use numbers and reason effectively), spatial (the ability to use the visual-spatial world to express ideas effectively), bodily-kinesthetic (the ability to use one’s total body to express ideas effectively), musical (the ability to express musical forms), interpersonal (the ability to respond effectively to other people), and intrapersonal (the ability to develop and use one’s own self-knowledge) (Gardner 1983). Gardner insists on calling these constructs intelligences and not talents, aptitudes or learning styles (Armstrong 1994). A key point is that most people can develop each intelligence to an adequate level of competency. Virtually everyone has the capacity to develop all seven intelligences to a reasonably high level of performance if given the appropriate encouragement, instruction and environmental conditions.

Although these two perspectives are theoretically different, they both support the assumption that instruction should address individual styles of learning and that some students learn best through different approaches. This project used these two different perspectives to explore how individual learning styles impact working with computers as a cognitive tool and if learning styles can change when the environment is technology rich and designed to encourage one model of instruction.

Method

Sample

A team of 15 students was assigned to this researcher by the school administration. The team was chosen based upon scheduling arrangements with the school and the researcher. The team was comprised of 12 male students and 3 females. The gender imbalance was seen as a definite disadvantage but due to scheduling problems and the nature of this being an exploratory study, this arrangement was accepted. The team was multicultural in make-up with 9 Caucasians, 5 Asians, and 1 Hispanic.

The Measures

The Learning Style Inventory (LSI) (Dunn, Dunn and Price 1989) was administered to the sample of students. This inventory obtains a profile of each student in twenty-two areas that, when identified as relevant areas, represent the way in which the individual prefers to study or concentrate.

The test is designed for grades 5 - 12 where students respond on a five-point Likert scale ranging from Strongly Disagree to Strongly Agree. There are 105 questions and from a student’s score an individual profile is calculated. The standard score scale ranges from 0 to 80 with a mean of 50 and a standard deviation of 10. The standard score is calculated based on the scores of more than 500,000 students who have completed the LSI.

A questionnaire was also administered to the students immediately following the LSI. The questionnaire surveyed each student’s previous knowledge of computers, motivational interest in technology, preference for working on a team, with a partner, or alone, and self-perception on the seven multiple intelligences that Gardner (1983) proposes.

Procedure

The four major methods of data gathering were weekly classroom observations, two interviews with the 15 students, administration of the LSI, and administration of the questionnaire to the sample of 15 students. This approach was selected because a flexible, exploratory method was needed that combined qualitative
analysis of observational reports with quantitative data gathered through the LSI and the questionnaire.

Findings

The Field Notes and Interviews

After a year of observations and in analyzing the field notes and the two interviews, a few major points emerge. The first is that technology clearly impacted the social context that exists and pervades almost every aspect of life at the school. The Academy fosters a vibrant and exciting environment where technology is being used as an integral tool in the total instructional process. Many students went from being computer novices to exploring the computer as a cognitive tool in sophisticated ways. In this context, learning and teaching are being actively redefined. Students do not sit passively at desks but are involved in projects whereby they are actively using the computer to solve problems, write notes and conduct research. As the research points out (Cohen 1995), computer-rich environments promote a more constructivist, team-oriented, collaborative approach to learning. This was supported by this research study. The context of the school was informal, supportive and seemingly chaotic at times, oftentimes a buzz of student voices talking, always a feeling that learning was taking place. Teachers were dedicated and concerned, students were involved in exploration and problem solving, and technology was an integral part of that social context.

Another major point that emerged from the field notes is that these gifted students wanted to be shown how to seek deeper connections and did not just want to merely use the computer as a tool. Many of the students were not "enamored" with just using the computer but became frustrated when they felt the project they were working on was not challenging them to use their minds and seek deeper connections. Those teachers that acted as "cognitive mentors" were respected and favored. When the students were not using computers for problem solving and higher reasoning, they became frustrated and bored.

Another point from the field notes was that technology impacted the way subject matter was presented and discussed. The subject matter was presented with a much more visual representation of the concepts, and computer projects sometimes seemed to determine the direction the class would go in. Such a visual emphasis oftentimes seemed to help many of the students who had language problems because of not being native speakers or were visual/kinesthetic learners.

The field notes also point out that some students whose learning style preferences were toward working alone and requiring more structured learning environments, may have felt some dissatisfaction with the constructivist approach used. Those students who displayed a more analytical, left-hemispheric dominance might require a different approach than the more global, right-hemispheric teaching style that was being predominantly used.

The LSI

The results of student responses by subscale on the LSI are summarized in Tables 1 and 2. Table 1 (see Tab. 1) summarizes high preference responses by subscale on the LSI, or those students who received a score of 60 or higher in each element. Table 2 (see Tab. 2) summarizes low preference responses by subscale on the LSI, or those students who received a score of 40 or lower in each element. The columns in both Tables list for each subscale: the frequency of responses for the first administration in 9/94, the percentage of responses for 9/94, the frequency of responses for the second administration in 6/95, the percentage of responses in 6/95, the difference in frequency of responses between the two administrations, and the difference in percentage between the two administrations. Any negative number indicates that the group was higher in preference at the second administration than in the first. Thus, in Table 1 under the subscale “Parent Motivated”, -14.7 difference in percentage means that in June, 1995 an increase of 14.7% of the group had a high preference for having parents around during studying. In the same table, under the subscale “Teacher Motivated”, 26.2 difference in percentage means that in June, 1995 a decrease of 26.2% of the group had a high preference for wanting teacher direction during studying.

Figures 1 and 2 (see Fig. 1 and Fig. 2) show a bar graph of the frequency of responses on selected LSI items for the first and second administration of the inventory. Each subscale has been categorized into high, medium and low. In the subscale “Learning Alone/Peers”, the high represents preference for working with peers and the low represents preference for working alone.
The Questionnaire

The results of the questionnaire on the seven forms of intelligence administered in the first month of schooling are summarized in Tables 3 and 4. Table 3 (see Tab. 3) summarizes the high preference responses on the Seven Forms of Intelligence. Table 4 (see Tab. 4) summarizes the low preference responses on the Seven Forms of Intelligence. Figures 3 and 4 (see Fig. 3 and Fig. 4) display bar graphs of the frequency of the Seven Forms of Intelligence at both administrations.
Conclusions

A major point that this study found is that student learning style can be affected by teaching style and the social context in which the learning is taking place. How computers are used within the environment seems to affect how a student learns, and will thereby affect certain learning style preferences. The social context of the classroom and school, in general, impacted all aspects of learning in this environment. There appears to be a relationship between learning style, social context of the school, and high use of technology within this school.

The use of technology impacted all aspects of the teaching/learning continuum and demanded new approaches to the curriculum. New ways of looking and exploring the curriculum emerged as teachers tried to integrate technology directly into the subject matter. Each teacher had a unique way of approaching computer literacy as technology became a tool that impacted each subject area in a unique and specific way. In Biology, statistical analysis on the computer was emphasized, while in American Studies databases, the Internet and HyperCard were incorporated, while in another class CAD was emphasized. The total impact was that teachers and students learned to view technology as a tool that can enhance each subject area in a different and specific way.

Technology also affected the unwritten curriculum, or the way he/she managed the discipline and rules pervading the classroom, changed as well. Students could be seen chatting about their weekend activities over the computer scanner and laughing at a joke while working at the computer. These “distractions” did not interrupt the learning process and were not stifled (unless a structured activity was occurring where expectations
demanded different sets of behavior). Rather, learning was seen as a much more natural process whereby conversation and discourse does not interfere with acquisition or application of knowledge.

Given that there appears to be a relationship between learning style, social context and technology, another major point from this study seems to be that a learning environment must support and encourage many different types of learning styles and help develop all forms of intelligence in a varied and rich environment. In an era when a constructivist approach to education is being promoted in many educational environments, care needs to be taken that students who may not prefer to learn in this particular style be accommodated.

Another major point from this study is that gifted students have specific needs which must be addressed. Gifted students desire opportunities to use computers as cognitive tools to explore deeper connections in a subject rather than merely use the technology as a vehicle to produce “glitzy” presentations without much depth. They desire to be pushed intellectually and want to be challenged.

In summary, this study has suggested that there is a relationship between learning style, social context, and use of technology. This is also impacted by the population of students that are involved in this environment. Care must be taken to address all these issues when designing, implementing or revising a curriculum.

References


The ‘Learning Station’: An Interactive Learning Environment for Distance Learners in Geographical Information Systems.

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Abstract: The UNIGIS ‘Learning Station’ is a computer based learning management tool for the postgraduate diploma in geographical information systems by distance learning. UNIGIS is an international network of Universities cooperating in the delivery of such courses. The students on UNIGIS courses are mature, mid-career professionals who study in addition to undertaking demanding full time jobs. The ‘Learning Station’ offers these students information about the course; resources for independent study; a structured set of exercises, assessments and feedback opportunities to accompany each study pack; and an integrated and easy way to interact with the course software. The ‘Learning Station’ has been piloted with two groups of students in the UK, and an evaluation of their experiences is presented here. General lessons for development of similar learning support tools are highlighted as the ‘Learning Station’ has been designed to be adaptable to other courses and groups of students.

Introduction - What is UNIGIS?

UNIGIS is an international network of Universities offering postgraduate diploma and MSc courses in Geographical Information Systems (GIS) which are based on a common curriculum, adapted and translated to meet local student needs. The students on UNIGIS courses are mainly professionals from fields such as central and local government, planning, utilities, energy, services, education and consultancy. By mid 1996 there will be over 300 students registered on UNIGIS courses. To meet the needs of UNIGIS students, careful attention has been given to methods and procedures for course delivery, feedback and assessment. There are special problems involved with the delivery of such a technical and practical subject as GIS by distance learning, but the course has proved successful and continues to expand. Full details of the course, including an evaluation of strengths and weaknesses to date can be found elsewhere [Reeve et al. 1993; Reeve et al. 1994; Petch et al. 1993].

A series of core modules, which are designed to be studied in sequence, make up the basic diploma course. These are supplemented by optional modules and hands-on workshops which allow each student to customize the course to their own needs. This basic model has been adapted to meet local needs in different countries. The modules are mailed to students and are completely self contained. Each one contains notes, reading materials, activities and exercises of various types. Activities and exercises may be computer-based since all students are required to have access to GIS and database software. They may include browsing through a computer-based storyboard or the manipulation of data in a database. Self-assessed exercises are provided for active learning and for revision at the end of major sections of text. Tutor-assessed exercises are also a part of each module, and these may involve report or essay writing, data analysis or another appropriate activity. The Diploma is entirely assessed by coursework. Module materials are comprehensively updated with each new
intake of students. At residential workshops there are opportunities for additional hands-on experience and
group activities. Students also receive a comprehensive set of administrative information that includes a course
study guide, a course handbook (containing timetables, staff profiles, course regulations, etc.), intermittent
course newsletters, and other relevant material. These documents exist in paper form and are sent to students by
post.

The Purpose of the UNIGIS 'Learning Station'

Experience running the UNIGIS diploma course over five years, and discussions regarding problems faced by
staff and students led to the development of the ‘Learning Station’. The problems faced are discussed in full in
[Cornelius et al. 1994] and together with questionnaire surveys, feedback sessions at workshops and informal
contact with students these have led to the identification of four main functions for the computer based 'Learning
Station'. These are advisor, informer, assessor and tutor:

i)  Advisor - the system needs to provide advice on practical matters including hardware requirements, common
software problems and academic matters such as course regulations. It should also assist students with the
management of their learning, helping to ensure the efficient use of study time by providing facilities for the
management of course materials and progress monitoring.

ii) Informer - the system should provide easy access to up to date information such as course newsletters,
deadlines for assessed work and dates of workshops. It should inform students of other resources that are
available to support their studies since resource such as libraries, databases and literature are out of reach for
many UNIGIS students.

iii) Assessor - the system should give immediate feedback on learning and provide self-assessment opportunities
since contact with tutors and assessors is necessarily limited on a distance learning course. The system
should provide students with the ability to track submission dates and record grades for tutor-assessed
assignments, enabling progress to be monitored throughout the course.

iv) Tutor/motivator - the system should provide access to software tutors, demonstrations of new topics and
access to 'real life' tutors. Since the course requires a wide range of information technology the use of a
straightforward interface in the system will help to focus learning on the topics under study, rather than
software difficulties. Linking together software required for the course should also help to reduce the steep
learning curve associated with the acquisition of new IT skills by some students. In addition, the system
should help to address the issues of isolation and de-motivation faced by many distance learning students by
encouraging electronic communication with the course team and other students.

The practical considerations outlined above provide sufficient justification for the development of the computer
based learning management system. However there are other factors. [Ellis et al. 1993] consider that the use of
enabling technologies such as hypertext allow teaching and learning styles to be well matched, in turn improving
motivation for learning. [Woodhead 1991] offers criteria for the assessment of the appropriateness of hypertext
learning tutorials. The Diploma meets all of these criteria. In particular, the current course is delivered using a
mix of textual and multimedia materials, all of which require regular updating and can be easily computerized.
Students require non-linear access to course information, and have the skills and the resources to access and
utilize a computer-based 'Learning Station' system.

Construction and Development of the 'Learning Station'

The 'Learning Station' is regarded as a learning management tool, not simply an instructor or computer-based
tutor. Thus, using the definition of computer managed learning provided by [Gold et al. 1991], it is software that
aims to manage both conventional and computer-based learning. This is achieved by linking computer-based
instruction tools, GIS and database software, communications software and specifically developed tools for the
management and structuring of learning. These are designed to be used in conjunction with the paper text. The
UNIGIS 'Learning Station' is not designed to be a multimedia version of the modules already produced in paper
form. It is a semi-structured, managed, learning environment that allows the student control, flexibility in
approach and the ability to monitor his or her own progress.

The framework for the 'Learning Station' has been constructed using the Windows development software,
Multimedia ToolBook CBT (Asymetrix). One of the criteria for development is that the 'Learning Station'
should run on a relatively low specification PC with Windows software. However, recognizing the rapid developments in telecommunications, and decreasing cost of PC hardware, the development environment must be able to take advantage of future enhancements in these areas.

The 'Learning Station' has been built in two main sections, reflecting the current situation of students as regards access to communications links. For those without access to a modem and Internet, the 'Learning Station' offers all that is necessary to complete the course including administrative information, exercises and access to software and databases. If the communications link is available, then the 'Learning Station' additionally facilitates access to the Internet. Material is organized in two main sections: the Information guide, and the Module guide. A help system, including 'Learning Station' tutorial, and navigation map are also provided.

Given the high standard of many existing CAL resources in GIS, it is part of the UNIGIS philosophy to include these where possible and appropriate as part of the tutor role for the 'Learning Station'. Thus, links to existing resources produced by UNIGIS team members (such as the map algebra tutorial produced by Josef Strobl and the 'House Hunting game' produced by members of the UK team) have been developed. Links to other external resources, such as the IDRISI tutorial package 'Getting Started in GIS' [Langford 1993], the Microsoft Windows tutorial and a range of GIS demonstrations produced by other third parties, are also provided.

The 'Learning Station' uses a variety of different software tools including hypertext, animation, interactive question and answer software, commercial GIS and database software and communications software. Hypertext has been used for many aspects of the informer and advisor roles required, including the presentation of course guides, handbooks and help systems. The inclusion of the complete module texts as hypertext documents is a development option. However, this is not favoured by the majority of students who prefer paper notes which can be studied at any location. Summary details for each module are, however, included. Animation is a useful tool for the demonstration of complex and time consuming GIS operations, as has been demonstrated by GISTutor [Raper and Green 1992]. In the 'Learning Station' it has been used for tutorial and storyboard type displays of operations that are not effectively illustrated on paper. ToolBook has been used to construct a set of self-check questions of a multiple choice and short answer nature. These are ideal for self assessment exercises and provide immediate feedback and suggestions for further work where problems are identified. With the paper versions of the module this type of feedback was missing and this meets the need for an assessor role for the 'Learning Station' suggested earlier. ACCESS (Microsoft), dBASE (Ashton Tate), IDRISI (Clarke University) and ARCVIEW (ESRI) are currently used by UNIGIS. The 'Learning Station' provides links to these where they are required for the visualization of case study data sets and for the completion of exercises or assessments.

Initially a pilot 'Learning Station' was produced for one module, half way through the course. Material is currently being developed for all course modules. A typical module includes:

i) Automatic loading of exercises and data from disks which arrive with paper-based materials.
ii) Self-assessed exercises. A variety of approaches to multiple choice questions have been implemented to elicit comment from users as to which suit their learning styles most effectively.
iii) Computer-based tutorials. For example, a short tutorial offering animation of common map algebra functions in raster GIS has been adapted from a German language tutorial written by Josef Strobl. This supplements static text-based diagrams very effectively.
iv) Annotated stories and virtual lectures. 'Slide shows' of computer screens illustrating case study data sets, referred to within the text, offer substantial advantages over paper-based reproductions of images. In a similar way, virtual lectures, supplementary notes and diagrams and self-check tests written to supplement module and workshop materials have been included.
v) Tutor-assessed exercises. Details are annotated with the help of icons into aims and objectives, deliverables and methods sections. Over the paper text these have the advantage of added visual impact, and direct access to the data and software required, including word processing software for report writing.
vii) Supplementary learning resources. These may include sample Internet pages, or suggested Internet sites for exploration. The 'Learning Station' also offers access to a comprehensive reference database that has been compiled by course staff.

Future developments for the 'Learning Station' include the creation of a more comprehensive 'virtual classroom'. Virtual lectures, including notes, diagrams and self-check tests have already been provided, and the idea of a virtual workshop, involving collaborative problem solving and multimedia presentations is being explored [Reeve and Heywood 1995].
Evaluation of the ‘Learning Station’

Two cohorts of UK based students have been surveyed using a comprehensive questionnaire addressing resources available to the students, use of the ‘Learning Station’, attitudes to the ‘Learning Station’ and learning styles. One group evaluated the pilot ‘Learning Station’ mid way through the course, where it was presented as a development in course materials. Comments from this group were mixed, although the majority were in favour of the system, and students commented that it would have been useful to have the ‘Learning Station’ available throughout their course. The second cohort was issued with the ‘Learning Station’ as part of course materials from the beginning of the course. They provided feedback on their experiences with the ‘Learning Station’ after the first module. In total 21 students have provided full feedback. All of these had used a computer prior to the course (predominantly for word processing). Over 40% obtained a computer (usually a 486) for the course. Over 90% of students felt that the ‘Learning Station’ could become an essential part of the course, and more than 60% felt that the ‘Learning Station’ encouraged greater autonomy and self direction in their learning. Over 60% disagreed with the statement that the ‘Learning Station’ was a gimmick. The feedback from the students is considered in terms of the four roles identified for the ‘Learning Station’.

i) Advisor - about 50% of the students used the ‘Learning Station’ to access information from the course handbook, and other technical information (particularly information on communications and the Internet). Some respondents felt that more details were required in these areas.

ii) Informer - again, about half of the students used the ‘Learning Station’ in this role. They looked particularly for recommended texts, the newsletter and dates of deadlines and workshops. They commented that information provided should be up to date and relevant and suggested that tutors should provide regular updates. They wanted to see a full reference database and to have, if possible, direct access to reading materials. They felt that the ‘Learning Station’ helped make information easily and readily accessible.

iii) Assessor - the students surveyed used the ‘Learning Station’ most frequently for undertaking self-assessment exercises. They found these exercises easy to use and felt the system improved the learning process. Less, just under half, felt that the ‘Learning Station’ provided helpful feedback or information on progress.

iv) Tutor/motivator - the ‘Learning Station’ offered interactive demonstrations and slide shows to illustrate some of the more graphical elements of GIS, and case studies. Students felt these were useful backups to the text, although in places they felt that more details would be useful.

Respondents were also asked about positive and negative aspects of the ‘Learning Station’. In general the positive points included easy access to course material and software, graphical shows and visual presentation of material to back up issues covered in the paper text. The self-assessed exercises again scored highly. Several individuals commented on the positive aspects for learning. For example, it was suggested that the ‘Learning Station’ provides an alternative source of study - ‘a change is as good as a rest’, that the ‘Learning Station’ assisted ‘learning by doing’ and provided motivation for learning.

Negative points and suggestions for developments focused on technical problems, and interestingly, the problems of reading text on-screen. Some students had faced technical problems with the setting up of the systems on particular machines. They requested a print screen facility and full help system. In addition, they need to read large chunks of text from the computer screen was felt to be far from ideal - the font used was criticized, as was the nature of the presentation, often using windows with scroll options. One user commented that the system made it impossible to browse through text, but required the reader to wait for the computer. Others were concerned about the fact that they did not want to spend more time in front of the computer screen.

Issues for Development

A number of challenges face the development of the ‘Learning Station’ [Cornelius et al. 1994]. First, electronic communications, despite wide use in the academic community, are less well used in many organizations. In 1995 only 30% of UNIGIS students in Austria had access to electronic mail, and less than 10% of students on the UK-based diploma were participating in the discussion list, although these numbers are increasing rapidly. Most students are new to Email and Internet, and to allow time for experience and skills in this area to develop, the electronic communication part of the ‘Learning Station’ is currently an optional extra. However, given the pace of current development and the increasing availability of local access to Internet providers electronic communications are likely to be essential in the near future. To prepare for this, sample off-line materials from
the Internet have been provided with the ‘Learning Station’, and the capabilities have been demonstrated to students at workshops.

Second, the costs of some of the multimedia technologies are still prohibitive for some students on a course of this nature. CD-ROM, for instance, would be ideal for the storage of included articles, video of case studies and discussion sessions and is therefore a development that will be built into the ‘Learning Station’ in anticipation of falling costs. Access to CD-ROM is likely to become a requirement for students on the Austria-based courses from 1996 since there are examples of externally produced data sets, conference proceedings, and software demonstrations already available on CD-ROM that are ideal resources for the diploma. Additionally, sound would be very useful, to allow explanations whilst case study images are viewed on screen, or to accompany virtual lectures. Experiments in these areas are being conducted and it seems likely that developments in PC technology and rapidly falling costs will help to promote home computing in a more general manner, thus placing the resources required within easy reach of all UNIGIS students in the near future.

There is also the more fundamental question of whether the quality of the learning process is actually improved by the availability of a CML tool such as the ‘Learning Station’. Although students clearly feel that there is a role for the ‘Learning Station’, and that it can improve their motivation for learning, there are problems in using the system. First, the ‘Learning Station’ is inappropriate for delivering large amounts of text based materials. Second, lack of detail, and unfinished sections are frustrating for users. Other findings [see Mason 1994 and Goodyear 1994] suggest that learning and motivation will be significantly improved for distance learning students through interaction with course materials and particularly through increased communication with staff and other students. There is little evidence yet that the ‘Learning Station’ is promoting increased communication with staff and other students, but there is some evidence to suggest that it is helping with the learning process by improving motivation, offering a variety of learning experience, and providing rapid feedback and access to learning resources.

Conclusions

The ‘Learning Station’ develops earlier ideas for computer-based tools for GIS education, and the methods being adopted are applicable to a wide range of GIS educational situations, including undergraduate resource-based learning, and professional updating. For UNIGIS distance learning students the ‘Learning Station’ has been designed to act as advisor, informer, assessor and tutor, since these students are outside the traditional classroom environment. The ‘Learning Station’ approach offers the opportunity to coordinate the wide variety of computer-based tools, including electronic communications, animation, existing CAL packages, and GIS and other software, which are already being used in the course. Evidence from evaluation of the system in a learning situation suggests that it will be used by students, and that they appreciate an easy to use system that makes course resources easy to access. In addition the ‘Learning Station’ has improved motivation for learning and increased feedback opportunities. If the problems of the resources available to home based learners, the difficulties of presenting text based materials on screen and limited access to communications and the Internet can be overcome, learning management tools like this, which offer more flexible and effective GIS education, will help to meet the challenges of life-long education in a complex and fast moving discipline such GIS.

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Teacher-Learners Cooperation Produces an Innovative Computer-Based Course

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Abstract: this work analyzes structure, development and use of a Computer-Based Learning package for Digital Electronics that is composed by a set of learning tools interconnected by a hypertextual shell. Learning is achieved by practicing with the tools, while the hypertext provides theoretical support and help. A peculiar aspect of this work is the role of the learners in the creation of the learning material: under properly defined rules, students are, at the same time, users, producers and evaluators of courseware. Together with pedagogical and technical issues, the cooperative development of courseware and the analysis of students’ feedback are important points that are treated on the paper.

1. The CBL Approach

The Computer-Based Learning (CBL) location involves a group of concepts and techniques, which has not been well defined yet, and refers to pedagogical applications of computers. Such a system, exploiting hypertext and multimedia structures, manages a fixed content and it is designed to play the role of instructor in the delivery of learning material. We describe the attempt to introduce CBL in the field of electronic engineering [Ponta & Parodi 93]: our CBL approach is enriched with learning tools, that are software applications able to process a content that is provided by the user.

Many studies have been made in the field of CBL, attempting to compare it with traditional methods of teaching. We believe instead that a more appropriate way to study the problem is to analyze the learning process, making a comparison between the traditional techniques (i.e. pencil-book) and the computer-based learning. In the traditional course, the learner was a quasi-passive observer and listener of knowledge transmitted by an external center (the teacher). With CBL (active learning), student is the new center of the learning process, building his/her own knowledge exploiting his/her own active experiences. These concepts are expressed clearly in [Schank, 94], where the author points out the main features of active learning paradigm. Moreover the Computer-Based Learning allows the introduction of more material than by conventional means and, taking advantage of multimedia technology, concepts can be introduced with more than one approach, making study more attractive.

2. The Methodologies of The Learning Environment

The CBL course (called in the following “courseware”) in Digital Systems Electronics (ESD) is a classical introduction to digital systems, targeted to students with no previous knowledge of digital electronics. The subjects are, essentially, combinational and sequential logic systems, including state machines and microprocessors. The learning environment is divided into four parts, representing the pedagogical activities upon which the course is based. The presentation of theory, concepts and other information is the first, followed by the interactive explanation of the theoretical material just introduced. Verification of learning is achieved in the third one, while practice of synthesis and analysis is the target of the last one. The learner is free to explore
the environment without constraints.

Figure 1: Learning Environment and Methodological Structure of The Courseware.

Our courseware gives a practical implementation to the learning environment described above [Fig. 1]. Independently of the specific subject taught, the four subdivisions of the learning environment roughly correspond to four different pedagogical methodologies adopted in the courseware. Each methodology is implemented using building blocks called “learning units”. A learning unit (LU) is defined as the smallest “cell” (or segment) that maintains a specific pedagogical function. In our case, a LU may be a definition, an example, a demonstration, and the like. The course is made of a large set of learning units with proper links and indexing. Such architecture is useful because it allows personalisation, reusability of the learning material and reliability of network transfer.

The first methodology analyzed is called “expositive”. Theory, definitions, hints and many other features that translate traditional textbooks in “electronic books” are typical examples of expositive materials. In our course a hypertextual environment is the default choice, with its capability of structuring text, images and links [Smeaton, 91] [Ponta et al., 91]. In some instances, exposition is enhanced by reducing the amount of text and replacing it with animations. Changing classical communication media with computer does not modify the position of the learner, who is still somehow a passive observer.

The second kind of methodology, the “demonstrative”, targets specifically the understanding phase of learning, trying to form an intuitive idea of a concept, through animations and pedagogical simulations, in which the student has a limited control of the process. Descriptions of processes that can be difficult to explain by text only become, in fact, very simple and intuitive if the text-based description is substituted, or integrated, with direct animation. A typical example of animation is the dynamic representation of the data flow in a microcomputer fetching and executing an instruction. The local simulations, that at a first look may appear similar to animations, are instead quite different. While the former simply “animate” a process every time in the same way, the latter allow the user to interact with the learning environment. They are, in fact, simplified software simulation of specific processes or networks that the learner can control by setting the values of some of the variables. An example of demonstrative methodology is represented by the reference solutions of past written examinations. They include local simulation of all Finite State Machine charts, animation of timing diagrams and assembly language programs. Animations and simulations have been developed using the features offered by hypertext authoring tools; as a consequence, they are embedded in the hypertext.

The interactive methodology applies to the testing part of the learning environment and is mainly characterized by an evaluation of the learner's answers. In our course, the interactive methodology is
implemented by tests and problem-solving workshops (PSW). Short, rapid multiple-choice and true-false quizzes (MCQ) have been built to recall all the topics of the course. In these tests wrong answers bring up text fields that explain why the answer was incorrect, and a score is generally computed and given to the student. The PSW approach attempts to be a guide in the development of an algorithm, let it be a state machine or a software program or else. Such task is difficult to teach because it requires, in addition to the knowledge of the rules, the conception of something that did not exist before. Same difference as from knowing the rules of the grammar and writing a text! Such exercises reduce to one only the possible design solutions: training for real design implies the removal of this limitation. This is achieved with the “tools” methodology.

The tools, general purpose simulators of digital networks and state machines and microprocessor emulator, are the more complex components of the courseware [Ponta & Donzellini 94]. They are custom-built applications with approximately the same characteristics of professional CAD tools for electronics, except that their design has been carried out with a strong pedagogical orientation. Their construction has required programming instruments beyond the hypertext's own language. The tools are the most important instruments to implement the “learning-by-doing” paradigm, as discussed in [Preliminary Analysis of Evaluation Data].

The course of Digital Systems Electronics is made of a wide collection of LU’s organized into a general index that is built as a virtual archive from which the student can access each pedagogical resource of the courseware. Formally the hypertextual index corresponds to the map of navigation trough the information in the hypertext and connected to it.

3. Courseware Development Environment

Interaction with students has played a very important role in the development of the courseware. In fact, they have played a double role, as users and developers at the same time. The course has been developed through four main phases [Fig. 2], that we analyze in detail.

In the first phase (planning) the teacher decomposes the course content in elementary units (the LU’s defined in the previous paragraph) and produces a list of the learning material to implement. Complexity and difficulty of implementation of the components change in a wide range: tools require higher programming skills than hypertext, while the latter takes advantage of better pedagogical capabilities.

In the second phase (interactive development) the students of the traditional course ESD, who have passed the final written examination with an high score, can choose to finalize it either by a regular oral test or by completing an assignment related to the courseware, chosen from the list produced in the previous phase. The majority of students develop a courseware component, in spite of the large workload requested. Very often the students create autonomously a work group of two or three people for the largest tasks. The work begins with a meeting between the students and the professor to specify the objectives and strategy of the work. They are given diskettes with examples of previous work and guidelines for the development of the material. Even if the work has no deadline, most students ultimate their job in a period from one to three months: obviously, this period is longer for applications like simulation tools and emulators which require special knowledge of programming languages such as C and Visual Basic. The students authors of the best tools have won a special award provided by Hewlett-Packard, that is the active sponsor of the project [HP-DLI 95].

During this period the students maintain the contact with the teacher who follows the progress and gives them advice. This process aims to exploit the best capabilities of each developer and ends with the delivery of the software, that is tested for functionality and effectiveness. However all the material produced at this level is raw (prototype) and cannot be used as it is. It's worth to note that by letting the students free to work almost independently on a given subject, the material produced, to some extent, reflects student's point of view on the argument developed. Students, in fact, communicate the fundamental concepts using a language that is generally quite well understood by their colleagues: this is one of the innovative aspects of this course.

The third phase deals with validation, quality test and standardization of the material produced during the previous step. The evaluation is carried out by other students with teacher's supervision, again as an assignment. The output is a final report with suggestions for changes. Most of the times the assignment includes the upgrade of the component under validation, while in other cases the upgraded version is prepared by someone else. The standardization of the components is necessary because we do not to impose a strict model at the moment of the production of the learning material. Therefore, the components need to be modified in order to appear with a common interface, to avoid disorientation to the learner; after a final supervision, the prototype becomes a unit of the course.
The last phase (linking and indexing) consists in the linking of the components between themselves to form the course “modules” [Brodland & Welstead, 91]. With the term “module” we define a set of learning units unified by a common subject. For example, the module “microprocessor” is formed by several hypertextual components (theoretical bases, description of the hardware, instruction set), other components with local simulations and animation (to demonstrate its functions and its programming), an interactive multiple-choice test and the general purpose emulator. The modules are connected together by a global index that allows the learner to search for and reach each LU, as discussed in [The Methodologies of the Learning Environment].

3. The Experiment

3.1 Courseware Distribution and Evaluation Criteria

The experiment with the CBL course, developed with the system described before, has taken place in parallel with the regular college course, during the academic year 1994-95. The first release of the course is made of approximately 20 Mbytes of courseware, stored for convenience in a compressed format on eight floppy disks. The CBL material has been made available to the students attending the academic class. Student have been able to access the CBL material by borrowing from the faculty library the diskettes to install in their PCs or using the courseware directly in a computer classroom.

The learners are, obviously, the target of all the efforts made to introduce the use of computers in education. Their opinions on computers and courseware are, therefore, extremely relevant. While is relatively simple to describe the use of the computers for learning, evaluating the effects that their use produces becomes much more complex. In order to find a direction for the development of our system, we have continually sought criticism and advice from students, with the conviction that their response is the most important. It goes without saying, also, that the CBL approach, to be viable, must gain wide acceptance by students.

The methodology used to evaluate the courseware consisted of summative and formative evaluation [Pagano, 92]. Summative evaluation refers to the evaluation of the finished courseware to assess the overall effectiveness of the learning material, checking how well the various parts of the CBL lessons work in a real educational setting. Formative evaluation refers to the improvement of the material by altering the learning components and producing a new generation of the software, through the collection of the students’ suggestions.
and critics.

3.2 Preliminary Analysis of Evaluation Data

Apart from the informal collection of data, obtained with personal interviews, a more general attempt to investigate student feedback has been carried out by means of an exhaustive questionnaire [Gupta & Buchanan, 93]. For conciseness, here we limit our analysis to data regarding the overall evaluation of the material and the assessment of the main category of components in terms of utility and use. While we keep in mind some limiting aspects of such a raw investigation (limited number of students, free use of courseware), we think that the analysis of the students’ responses should be carried anyway, to gather essential data for the prosecution of our work.

We have found that, in a group of 142 students, about half of them (47% n = 67) have installed all or part of the CBL course and studied with it. The following analysis deals with the students’ evaluation of the specific courseware components. The use of the courseware is considered very simple by the great majority of student-users (36% n = 51), the material is useful for large part of them (35% n = 49) and it has been globally appreciated (average value = 3.53/5).

![Figure 3: Student-Users’ Evaluation of Digital Electronics Courseware](image)

(a) usefulness of expositive material;     (b) usefulness of simulators/emulators.

(1 = useless   5 = very useful)

The students’ assessment of the advantages of the courseware in relation to the traditional course materials (textbooks, course notes and syllabi) reaches an average value of 3.28/5: this data demonstrates that our CBL is not considered producing a decisive improvement of the learning process. This result is very important and deserves an in-depth reflection. Given the fact that the courseware has been distributed on voluntary bases and, consequently, the users are the persons that have voluntarily chosen to follow the CBL course, this conclusion proves, at least, that the responses are unbiased. It must be noted, also, that, in spite of the use of the CBL for teaching, the final examination was still traditional (paper and pencil) and represent a loss of continuity with the CBL approach. But, eventually, we must take good note of the fact that, very likely, learning processes are somewhat independent of methods chosen for the delivery of knowledge and, in some extent, beyond the limits of our investigation.

Figure 3 is particularly remarkable within this short analysis, because it summarizes the students’ judgment about the two main kind of components in the courseware: expositive material and tools [Fig. 3a] [Fig. 3b]. We stress the fact that the two graphs differ deeply in the distribution of the evaluation: the left one is concentrated near the middle values and the right one is shifted towards the high values. The students generally prefer practising with the tools instead of reading hypertextual material or watching simple animations. We interpret this result as the confirmation of our conviction that hypertext-based theoretical lessons are less effective than interactive tools. The learning-by-doing paradigm is really the way to proceed in the implementation of CBL application, at least in scientific and technological fields.

4. Conclusions and Future Activities
The CBL course has been used by a number of students exceeding our forecast. The assumption of the relevance of the “learning by doing” paradigm has been fully confirmed, with the corollary that expositive, non interactive material is acceptable as a part of a CBL course only if very well done and used in limited quantity. As a byproduct of the effort of producing the courseware in strict cooperation with the learners, we have personally realized the improvement of technical skills and communication capabilities of the students that have worked as developers and, on the teachers’ side, an increased awareness of the problems the students are facing in their learning.

We have no reliable data on the quality of the learning material, because our courseware is still in an optimization phase and a judgment on its quality is meaningful only when compared with other material of the same kind. Such analysis will be attempted with the new release of the course: we plan to develop new learning material and improve the contents of the existing one, enhancing its modularity and re-usability. Besides, we cannot separate the effects of the CBL instruction from the traditional one: we expect to collect data with a new experiment of a teacherless class to be held in the Academic Year 96, under the European project ARIADNE [ARIADNE 96].

5. References


Abstract: Since February, 1994, our project team has worked collaboratively to build "ScienceSpace," a collection of virtual worlds designed to aid students in mastering challenging concepts in science. Our goal is to develop an overarching theory of how learning difficult, abstract material can be strongly enhanced by multisensory "immersion" (based on 3-D representations; multiple perspectives and frames of reference; a multimodal interface; simultaneous visual, auditory, and haptic feedback; and types of interaction unavailable in the real world). ScienceSpace now consists of three worlds—NewtonWorld, MaxwellWorld, and PaulingWorld—in various states of maturity. Based on lessons learned from our research studies, we are developing design heuristics generalizable to a variety of educational environments.

Exemplary pedagogy in science education should develop learners' abilities to intuitively understand how the natural world functions before inculcating the formal representations and reasoning skills that scientists use. In other words, fostering in students the capability to qualitatively predict the behavior of the objects in the universe is initially more important than teaching them to manipulate quantitative formulas. Through using multisensory immersion in virtual realities customized for education, we believe that complex, abstract material now considered too difficult for many students—and taught even to advanced learners only at the college level—could be mastered by most students in middle school and high school.

The virtual reality interface has the potential to complement existing approaches to science instruction through creating immersive inquiry environments for learners' knowledge construction (Dede et al. 1994). By themselves becoming part of a phenomenon (e.g., a student becomes a point mass, undergoing collisions in a frictionless artificial reality), learners gain direct experiential intuitions about how the natural world operates. Good instructional design can make the aspects of virtual environments useful in understanding scientific principles most salient to learners' senses.

As one illustration, in two-dimensional Newtonian microworlds students often ignore objects' velocities, instead focusing on position. In a virtual reality environment, learners themselves can be moving, centering their attention on velocity as a variable; and designers can heighten this saliency by using multisensory cues to convey multiple, simultaneous representations of relative speeds. The novel perspective of oneself experiencing
and shaping a natural phenomenon, instead of acting as a passive observer, is intrinsically motivating. Transducing data and abstract concepts (e.g., acceleration) into multisensory representations is also a powerful means of enhancing understanding. Under these conditions, learners may be able to construct mental models of phenomena that have no counterpart in their everyday experience.

The Virtual Worlds of ScienceSpace

Since February, 1994, our project team has worked collaboratively to build "ScienceSpace," a collection of virtual worlds designed to aid students in mastering challenging concepts in science. ScienceSpace now consists of three worlds—NewtonWorld, MaxwellWorld, and PaulingWorld—in various states of maturity. NewtonWorld provides an environment for investigating the kinematics and dynamics of one-dimensional motion. MaxwellWorld supports the exploration of electrostatics, leading up to the concept of Gauss' Law. PaulingWorld, the most recent addition, enables the study of molecular structures via various representations.

All three worlds have been built using a polygonal geometry. Colored, shaded polygons and textures are used to produce detailed objects. These objects are linked together and given behaviors through the use of NASA-developed software that defines the virtual worlds and connects them to underlying physical simulations. Interactivity is achieved through the linkage of external devices (e.g., a head-mounted display) using this same software. Finally, graphics rendering, collision detection, and lighting models are provided by other NASA-developed software. The key hardware items used are a high-performance graphics workstation with two video output channels; a color, stereoscopic head-mounted display; a high-quality sound system; a magnetic tracking system for the head and both hands; and, in some cases, a haptic display. Interaction in these worlds is principally carried out with a "3-Ball," a three-dimensional mouse.

Description of NewtonWorld

NewtonWorld is intended for exploration of Newton's Laws of Motion, as well as the conservation of both kinetic energy and linear momentum. Students spend time in and around an activity area, which is an open "corridor" created by a colonnade on each side and a wall at each end. In one-dimension along the axis of the corridor, two balls move and rebound from each other and the walls. Students interact with NewtonWorld using a "virtual hand" and a menu system, which they access by selecting a small 3-Ball icon in the upper left corner of the HMD's display. Learners can launch and catch balls of various masses and can "beam" from the ball into and among cameras strategically placed around the corridor. The balls move in one dimension along the corridor, rebounding when they collide with each other or the walls. Equal spacing of the columns and of lines on the corridor floor aids learners in judging distance and speed. Signs on the walls indicate the presence/absence of gravity or friction.

Multisensory cues help students experience phenomena and direct their attention to important factors such as mass, velocity, and energy. For example, potential energy is made salient through tactile and visual cues, and velocity through auditory and visual cues. Currently, the presence of potential energy before launch is represented by a tightly coiled spring, as well as vibrations in a special vest users wear that communicates haptic sensations. As the ball is launched and potential energy becomes kinetic energy, the spring uncoils and the energy vibrations cease. The balls now begin to cast "shadows" whose areas are directly proportional to the amount of kinetic energy associated with each ball. On impact, when kinetic energy is instantly changed to potential energy and then back to kinetic energy again, the shadows disappear and the vest briefly vibrates. To aid students in judging the velocities of the balls relative to one another, we have the columns light and chime as the balls pass. Additionally, we provide multiple representations of phenomena by allowing students to assume the sensory perspectives of various objects in the world. For example, students can become one of the balls in the corridor, a camera attached to the center-of-mass of the bouncing balls, or a movable camera hovering above the corridor.

To guide the learning process, we provide scaffolding that enables learners to advance from basic to more advanced activities. Students begin their guided inquiry in a world without gravity or friction, allowing them to perceive physics phenomena that are otherwise obscured by these forces. They can launch and catch balls of various masses and can view the collisions from several viewpoints. These activities provide an immersive experience of often counter-intuitive phenomena. By instructing students to make predictions about upcoming events, directly experience them, and then explain what they experienced, we encourage learners to question
their intuitions and refine their mental models. We have developed detailed human subjects protocols that lead students through a progression of learning activities, carefully documenting their knowledge before and after.

Description of MaxwellWorld

Our second virtual world was built to incorporate "lessons learned" from usability studies of NewtonWorld. This world has been designed to enable the examination of the nature of electrostatic forces and fields, to aid students in understanding the concept of electric flux, and to help them empirically "discover" Gauss's Law. MaxwellWorld occupies a cube approximately one meter on a side with Cartesian axes displayed for convenient reference. The small size of the world produces large parallax when viewed from nearby, making its three-dimensional nature quite apparent. Menus and the 3-Ball are used for interaction in this world.

Unlike NewtonWorld's menus, the menus in MaxwellWorld are attached to the left wrist just as a wristwatch would be (for left-handed users, the menu location can be on the right hand). This allows the menus to be removed from the field of view, but keeps them immediately accessible, since users always "knows" where their hands are located. The index finger of the user's graphically depicted right hand is used to select menu items, and the 3-Ball button is depressed to execute a selection. Executions are confirmed by audible chimes. Navigation in MaxwellWorld is accomplished by selecting the navigation mode, pointing the index finger in the desired direction, and depressing the mouse button.

Using their graphical index finger, students can place both positive and negative charges of various relative magnitudes into the world. Once a charge configuration is established, the force on a positive test charge, electric field lines, potentials, surfaces of equipotential, and lines of electric flux through surfaces can all be instantiated, easily observed, and controlled interactively. For example, the tip of the index finger can be attached to a small, positive test charge, and a force vector associated with the charge depicts both the magnitude and direction of the force of the test charge (and, hence, the electric field) at any point in the workspace. A series of test charges can be "dropped" and used to visualize the nature of the electric field throughout a region.

In a like manner, an electric field line can be attached to one of the charges and to the index finger. A student can then move his or her finger to any point in the workspace and see the field line that connects that point to one of the charges. MaxwellWorld can also display many electric field lines to give students a view of the field produced by a charge configuration. In another mode of operation, the tip of the index finger becomes an electric "potential" meter that, through a simple color map and a "=" or "-" sign on the finger tip, allows students to explore the distribution of potential in the world.

Via the production of a "Gaussian" surface, the flux of the electric field through that surface can be visually measured. Spherical surfaces (Gaussian or equipotential) can be formed anywhere in the workspace by using the index finger to anchor the center of the sphere and then define the initial radius of the sphere. Upon activation, the surface grows from the selected radius terminus until a closed surface is formed. In the case of equipotential surfaces, the electric forces at any point on the surface can be shown as a color mapped onto the surface at that point. A point on the surface can be "grabbed" to expand or shrink the surface's radius, and its anchor can be moved at will.

Description of PaulingWorld

The most recently-developed virtual environment—PaulingWorld—has been created to serve as both a teaching and a "research" tool. This virtual environment was initially built by a single person over six weeks, using our software development tools and deriving its basic structure and interaction metaphors directly from MaxwellWorld. PaulingWorld allows one to examine the structure of both small and large molecules from any viewpoint and in a number of single or mixed representations. One moves between representations by using the same menu approach that MaxwellWorld provides. Molecules can be represented in ball-and-stick form, as vanderWaals' spheres, as a "wireframe" backbone, as coded sticks, and as icons that replace repetitive structures.

In the latter case, the icons can be interrogated by selecting them with the index finger and depressing the mouse button. The icon is then replaced by a complete representation. Thus, the macrostructure of the molecule remains "iconic," while the region of interest is depicted in a representation of choice. In the ball-and-stick and
the sphere representations, texture maps are used to give a visual cue for each atom type (e.g., carbon atoms have with a charcoal-like texture).

To support the rapid examination of various molecules, structural data can be read in directly from pdb (protein database) files that are widely available on the WorldWide Web, allowing a new molecule of interest to be built in a few minutes. Future extensions planned for PaulingWorld include the display of equipotential surfaces (implemented as in MaxwellWorld) and the provision for interactively exploring the effects of atom removal and substitution through direct links to molecular modeling applications.

Lessons Learned FromScienceSpace

We have developed elaborate assessment methodologies for evaluating the usability and learnability of our ScienceSpace Worlds (Salzman, Dede, & Loftin 1995). To date, we have performed three formative evaluations of NewtonWorld and one formative evaluation of MaxwellWorld:

NewtonWorld

• usability evaluations - In these evaluations, we focused on interaction styles and usability of the virtual reality interface, as well as NewtonWorld's general learning metaphor. Nine high school students participated.

• physics educator surveys - Through surveys, we gathered feedback and guidance from 100 physics educators who experienced NewtonWorld at a national conference.

• learning evaluations - These evaluations focused on misconception remediation and on learning with regard to factors such as energy, mass, force, acceleration, and velocity. Additionally, we examined how multisensory cues influenced learning and motivation. Thirty high school students who had completed at least one physics course participated in these evaluations.

MaxwellWorld

• learning evaluations - These evaluations are designed to assess how effective the virtual environment is as a tool for learning about electric fields and remediating misconceptions. 14 high school and 4 college students have so far participated in these studies, completing from 1 to 3 lessons in MaxwellWorld.

Based on lessons learned from the results of these ScienceSpace research studies, we are developing design heuristics, assessment methodologies, and insights generalizable to a wide range of educational environments.

Design Heuristics

From the beginning of this project, workers in Houston and Virginia have collaborated on both the design and development of the worlds that comprise ScienceSpace. Developers at each site can view visual displays at both sites and readily exchange software. This project has made very rapid progress due to this collaboration approach and to the ability to obtain almost immediate feedback when changes, refinements, and additions are made to a given virtual world. The most critical lesson learned is value of a development team composed of individuals with a wide range of education, experience, and creative energy. Among team members are engineers, psychologists, computer scientists, precollege teachers and students, a former architect, and an artist.

Our research suggests that multisensory immersion for learning depends on actional and symbolic and sensory factors. Inducing actional immersion involves empowering the participant in a virtual environment to initiate actions that have novel, intriguing consequences. For example, when a baby is learning to walk, the degree of concentration this activity creates in the child is extraordinary. Discovering new capabilities to shape one's environment is highly motivating and sharply focuses attention.

In contrast, inducing a participant's symbolic immersion involves triggering powerful semantic associations via the content of a virtual environment. As an illustration, reading a horror novel at midnight in a strange house builds a mounting sense of terror, even though one's physical context is unchanging and rationally safe. Invoking intellectual, emotional, and normative archetypes deepens one's virtual experience by imposing an complex overlay of associative mental models.

Adding stereoscopic images, highly directional and realistic sound, tactile force-feedback, a visual field even wider than IMAX, and the ability to interact with the virtual world through natural physical actions produces a profound sensation of "being there," as opposed to watching. Because common sense responses to physical
stimuli work in artificial realities, the learner quickly develops feelings of mastery, rather than the helplessness and frustration that are typical when first attempting to use an unfamiliar interface or operating system.

We are finding that new theories of instructional design are needed to develop worlds based on these heuristics. Standard approaches to building 2-D microworlds (graphical user interfaces, activities based around a planar context) fail badly when scaled to developing 3-D experiences. Multimodal interaction with multisensory output adds additional degrees of complexity. However, we are shortening our development process as we evolve design heuristics, tools, interfaces, and peripherals uniquely based around virtual reality.
Assessment Techniques and Protocols

Conventional human subjects protocols are inadequate for assessing the usability and learnability of virtual worlds. Although infrequent, potential side effects such as “simulator sickness” mandate the inclusion of special questions and protections to ensure users’ comfort. Moreover, because each person evolves a unique psychomotor approach to interacting with the physical context, individuals have much more varied responses to 3-D, multimodal interfaces than to the standard 2-D graphical user interface with menus, windows, and mouse. As a result, portions of our protocols must center on calibrating and customizing the virtual world’s interface to that particular learner. Also, evaluating the multisensory dimensions of an immersive virtual world adds an additional dimension of complexity to the assessment process.

We have developed extensive assessment methodologies and instruments for studying the worlds we have created. In addition, we are videotaping the hours of time we spend with each subject, studying these records for additional insights. This careful evaluation strategy is generating data from which we are gaining a picture of how immersion can enhance learning, as well as how virtual reality’s usability can be enhanced. Beyond our own work, the strategies underlying these assessment methodologies and instruments are generalizable to a wide range of synthetic environments and virtual worlds and thus are an important product of this project.

Challenges in Current Virtual Reality Interfaces

We have identified the following usability issues characteristic of virtual reality interfaces:

- Students exhibit noticeable individual differences in their interaction styles, abilities to interact with the 3-D environment, and susceptibility to simulator sickness.
- Immersion does present some challenges for lesson administration (for example, students in the head-mounted display are not able to access written instructions or to complete written questions.) We have found that verbal interaction works well.
- Limitations of the physical design and optics in today's head-mounted displays may cause discomfort for users. Since the visual display is an integral part of interaction and communication of information in these learning environments, these limitations are a current hindrance to usability and learning.
- Spreading lessons over multiple VR sessions appears to be more effective than covering many topics in a single session. While students began to challenge their misconceptions during a single 3-hour NewtonWorld session, many had trouble synthesizing their learning during post-testing. We believe that factors such as fatigue and cognitive overhead in mastering the interface influenced these outcomes. In contrast, our MaxwellWorld evaluations were completed over multiple sessions, tackling fewer topics during each session, and dedicating less time per session to pre- or post-testing. Reviews and post-tests demonstrated that students were better able to retain and integrate information over multiple lessons.

In our judgment, none of these issues precludes developing compelling learning experiences in virtual reality.

Learning and Knowledge Representation

Our goal is to develop an overarching theory of how learning difficult, abstract material can be strongly enhanced by multisensory “immersion” (based on 3-D representations; multiple perspectives and frames of reference; a multimodal interface; simultaneous visual, auditory, and haptic feedback; and types of interaction unavailable in the real world). Illustrative themes applicable across all the virtual worlds we have created are:

- Multisensory cues can engage learners, direct their attention to important behaviors and relationships, help students better understand different sensory perspectives, prevent interaction errors through feedback cues, and enhance perceived ease of use.
- The introduction of new representations and perspectives can help students gain insights for remediating misconceptions formed through traditional instruction (e.g., many representations used by physicists are misleading for learners), as well as aiding learners in developing correct mental models. Our research indicates that qualitative representations (e.g., shadows showing kinetic energy in NewtonWorld) increase saliency for crucial features of both phenomena and traditional representations.
Allowing multimodal interaction (voice commands, gestures, menus, virtual controls, and physical controls) facilitates usability and seems to enhance learning. Multimodal commands offer flexibility to individuals, allowing them to adapt the interaction to their own interaction preferences and to distribute attention when performing learning activities. For example, some learners prefer to use voice commands so that they need not redirect their attention from the phenomena of interest to a menu system. (However, if virtual worlds are designed for collaborative learning, voice may be a less desirable alternative.)

Initial experiences in working with students and teachers in MaxwellWorld suggest collaborative learning may be achievable by having two or more students working together and taking turns "guiding the interaction," "recording observations," and "experiencing activities" in the virtual reality. Extending this to collaboration among multiple learners co-located in a shared synthetic environment may further augment learning outcomes.

In general, usability of the virtual environment appears to enhance learning. However, optimizing the interface for usability does not necessarily optimize for learning. We have found instances in which changes to make the user interface more usable may actually impede learning. For example, in NewtonWorld to use size as an indication of a ball's mass is facile for learners, but would reinforce a common misconception that mass correlates with volume.

Our goal is to develop an overarching theory of how learning difficult, abstract material can be strongly enhanced by multisensory "immersion" (based on 3-D representations; multiple perspectives and frames of reference; a multimodal interface; simultaneous visual, auditory, and haptic feedback; and types of interaction unavailable in the real world).

Conclusion

To date, uses of information technology to enhance constructivist learning environments have centered on creating computational tools and virtual representations that students can manipulate. As learners interpret experience to refine their mental models, computational tools that complement human memory and intelligence are made available. In parallel, transitional objects (such as Logo's "turtle") are used to facilitate translating personal experience into abstract symbols. Thus, technology-enhanced constructivist learning currently focuses on how representations and applications can mediate interactions among learners and natural phenomena.

However, the high performance computing and communications capabilities driving the deployment of the National Information Infrastructure create a new possibility. Like Alice walking through the looking glass, learners can immerse themselves in distributed, synthetic environments, becoming "avatars" who vicariously collaborate and learn-by-doing using virtual artifacts to construct knowledge. Evolving beyond technology-mediated interactions between students and phenomena to technological instantiation of learners themselves and reality itself shifts the focus of constructivism: from peripherally enhancing how a student interprets a typical interaction with the external world to "magically" shaping the fundamental nature of how learners experience their physical and social context (Dede 1995).

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SLIM: A Model For Automatic Tutoring Of Language Skills

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Abstract: SLIM is a prototype interactive multimedia self-learning linguistic software for foreign language students at beginner - false beginner level. It allows students to work both in an autonomous self-directed mode or in away of programmed learning in which the process of self-instruction is preprogrammed and monitored. In this latter mode it is supervised by an Automatic Tutor. Audiovisual materials are partially taken from commercially available courses: all words and utterances of the course have been classified in the Linguistic Knowledge Database both in orthographic and phonetic form, from all possible linguistic aspects. The most outstanding feature of SLIM is the use of speech analysis and recognition which is a fundamental aspect of all second language learning programmes. We also assume that a learning model is the outcome of the interaction between Student Model and Language Tutor where the former embodies Learning Goals and the latter Pedagogical and Linguistic Knowledge.

1. INTRODUCTION

SLIM - Interactive Multimedia self-learning Linguistic Software, is a multimedia course for self-instruction characterized by a software which allows students to work both in an autonomous and independent self-directed mode or in a way of programmed learning in which the whole process of self-instruction is preprogrammed and monitored. At present, the prototype we are working at is directed to real and false beginners of both western languages like Italian, English and French, and eastern languages like Chinese and Japanese.

Self-instructional materials should have all the features good language teaching material have - interest, variety, clarity and so on. However the following points seem paramount: i. a clear statement of goals; ii. meaningful language input; iii. a sufficient number of exercise materials and of activities - their feasibility for self-instructional use; iv. individualisation and flexibility of materials; v. learning instructions in mother tongue for the levels considered herewith information in each unit giving advice on the order in which various activities should be done, how they are to be done; how much time they should take, whether they should be done over a short time interval or paced over a number of days; vi. language learning advice - it's essential for the learner to be told about how to tackle the job of language learning; vi. feedback and tests.

The course may be accessed in two modalities, according to students' attitudes:
1. Free Modality, self-access for self-directed students with no supervision by the Automatic Tutor (hence AT);
2. Guided Modality, self-access for beginners who use self-contained materials which are internally programmed and supervised by the AT.

In the first modality, the courseware is available with free access over each component, so that one can simply decide to organize an individualized path through them.

In either case, there is continuous support to the learners when they decide to engage themselves in one or the other modality, in order to advise them as to the setting up of goals which are adequate to their previous knowledge, expectations, and needs. The course is introduced by a general presentation where all different modules and activities are illustrated and exemplified. In addition, each module has been supplied with a Help facility, a sort of a Coach, which illustrates pedagogical issues relevant to the current exercise.

In the Guided Modality, the software is organized into Activities and Modules. Responsibility for the learning processes and corresponding tasks as well as for the decision-making processes for learning is expressly built into the materials. In order to do this the course is programmed in such a way as to allow for graduality in the presentation of materials and to include effective tools for self-assessment. For sure, learners that assess themselves should be aware of how well they achieve learning tasks, and have a reasonable idea of their level of proficiency.
In the Free Modality activity units are freely accessible from a database structure in which students may access them starting from goals. Students can design their own courses, the ways that the achievement of their selected goals may be assessed as well as when to take their tests. In other words, students may select preferred learning modes and strategies. It is clear that in this second mode, materials are proposed without any internal structure and students should be aware of their needs.

2. COURSEWARE ARCHITECTURE

In what follows, automatic tutoring will be described in terms of interaction between Student Model and Language Tutor which in turn is made up of a Pedagogical Component and a Linguistic Knowledge Database.

2.1 The Student Model
The Student Model encompasses both a statement of Learning Goals and an Assessment of Student’s Skills. Goals are ranked according to intrinsic grammatical difficulty levels, which in our system are graded up to Six Levels. Student’s Skills may also be graded from None up to Six Grade where each Skill maybe assessed separately and receive a different type of evaluation. According to student’s performance in Placement or Entry Tests, and to his statement of Learning Goals his Model will be constructed from the Tutor and an Ideal Curriculum or Learning Path shown to the student. The Ideal Learning Path includes all activities organized as a sequence of Tasks and a number of Milestones depending on Learning Goals. In turn, Learning Goals may be stated into two different modes: Mode 1 allows the student to access and highlight a number of different Communicative Functions, which in turn will automatically address Grammatical, Lexical, Semantic and Pragmatic Goals as exemplified by Audio video Learning Units. Mode 2 allows the student to choose among one of Six Grades where each one again addresses a number of Communicative Functions regarded as the most adequate for a certain level of knowledge of the language (see below).

2.2 The Language Tutor
As discussed above, the Language Tutor is the supervisor and has access to all components. It also has two special components: the Pedagogical Component and the Linguistic Knowledge Database (hence LKD). Before discussing in some detail the contents of these components, we shall outline the interactive part of the system. After the student has taken some test for entry level evaluation or for assessment purposes, the Tutor creates a Student Model which is made up of personal information from the student and a Learning Path. Every
subsequent action on the Model is intended as some form of Update of the Learning Path. Any Update action is motivated by the Pedagogical Component and by the intervention of some form of Warning or Advice from the Helping Component.

By accessing the LKD the Tutor creates the Ideal Learning Path which will be subsequently Updated whenever the student enters the system and engages in some exercise. Assessment is done locally by each individual Didactic Module making up some specific Linguistic Activity. Besides, the Pedagogical Component has the further task of evaluating student’s performance with reference to its Learning Path, in order to execute some adjustment. Adjustment may be of two kinds: Task Deletion and Task Addition. Every time some adjustment takes place, the Tutor may have to issue some Message to praise or to advise the student.

The LKD is then activated by the Tutor every time the student completes exercises in one Module of Linguistic Activities contained in the Learning Path. The student’s performance is assessed in real time according to type and modality of execution of the exercise. The student may decide to repeat the same exercise as many times as he likes, and iterative assessment will take place. As soon as the student leaves the Module, the Tutor is called and a list of results are passed for global evaluation. Helping Facilities are embodied from two hypertexts: a Grammar, and a Phonetics Course, all helping messages are built around them. By matching the linguistic contents of the exercise with the LKD and by computing repetitions and performance overall time, a total proficiency mark will be issued.

The Tutor reasons according to Macrolevels, as explained here below and Updates the Learning Path if needed. In turn Macrolevels refer to single specific items contained in the LKD by connecting to Microlevels and to Phonetics while at the same time having capabilities related to overall Learning Goals.

3. STUDENT’S SKILLS AND LINGUISTIC KNOWLEDGEDATABASE

Knowing a foreign language is a process that involves all communicative skills of the student. In particular it regards: a. passive abilities like understanding spoken and written linguistic messages; b. active abilities like writing and speaking in the target language. In turn, these skills may be further decomposed into their basic constituent: 1. acquisition of a base lexicon made up of a certain number of words; 2. acquisition of the basic grammar rules and grammatical words; 3. acquisition of the basic syntax and semantics; 4. acquisition of the phonetics, phonology and prosody of L2. Following a communicative approach, all these learning items must be transposed into a basic communicative environment in which the language must be adequately coupled to cultural issues and knowledge of the world related to the target language.

Supposing now to make a list of linguistic items, be they lexical items, grammatical items, grammar rules, syntactic and semantic structural rules, phonetic and phonological rules as well as morphophonological and prosodic rules of the language. These items have been organized into six levels of difficulty, determined both by objective and by contrastive criteria. The task of the AT is that of supervising the transition from one level onto the other, once the entry level of the student has been ascertained by objective placement tests. For sure, the AT will use achievement and proficiency tests during the course in order to establish the increase in proficiency achieved by keeping a record of all activities and tests carried out by the student and by reacting to the Milestones. However, and this is paramount, the AT will monitor all activities and determine whether the student needs remedial activity or not.

As to levels, we refer ourselves to the ESU Framework (Carrol, West 1989) which introduces a Yardstick for different types of linguistic performance scales according to language use and skill. Our course addresses the first four levels in a ladder made up of 9 levels. We assume that this last level is adequately addressed by an advanced course, whereas an intermediate course of English will suitably address levels going from 4 to 6.

3.1 Topics, Communicative Functions and Semantic Notions

In Free Modality the student will enter the course from a list of Main Topics which in turn are decomposed into Communicative Functions which refer to semantic notions. Functions may belong more naturally to one or the other Topic, thus cutting vertically the list of contents of a course; on the contrary semantic or conceptual notions cut horizontally each topic. The same applies to grammar rules which could be assigned difficulty scores according to an evaluation metric which is commonplace amongst language teachers, thus dividing up the grammar rule universe into levels; at the same time, these rules might be scattered at random amongst topics and be independent of the topic the student is currently learning.

We take a simple and cursory list of typical survival or general syllabus of a course for foreign language learners includes all or part of the following themes or topics like the one provided by Video English by the British
Council (Bury, McGovern, Potter 1983): suppose now we start up by regarding some communicative function as being intrinsically more pragmatically relevant, we shall end up with a rank list as follows:

All these communicative functions may be given a compact organization within the following more general six functions or macrofunctions:
1. ASK; GIVE, OFFER, CONSENT; 2. DESCRIBE, INFORM; 3. SOCIALIZE; 4. ASSERT, SAY, REPLY; 5. EXPRESS EMOTIONS, MODALITIES; 6. MENTAL ATTITUDES;

Each such macrofunction is linked to functions indicated above. In the communicative based approach to language learning, what comes first - as Level 1 - should be related to communicative activities that usually come first in real life situations. For instance, before starting a conversation people exchange greetings, and soon. However, we may assume that the rank list above should be regarded as a functionally relevant subdivision of Tasks, which however could be interleaved with situations at all levels. The ranking thus can be used as a simple subdivision into difficulty rating, from the less to the more difficult to learn.

3.2 Language Skills and Macrolevels
They are the basic skills, i. Listening, ii. Reading, iii. Metalinguistic competence, iv. Writing; v. Speaking

3.2.1 MACROLEVEL I
It is the basic level of knowledge of L2 at which learners are able to intervene productively in the most common communicative situations. To this aim they use the morphosyntactic structure specified below, and can understand texts both oral and written, with the lexicon included in the Base Vocabulary.

3.2.2 MACROLEVEL II
Learners acquire greater self-assurance and self-consciousness of previously learned materials, as well as increase their ability to intervene actively in much larger communicative situations both in the oral and written skills. Increase proficiency in the socio-cultural aspects of L2.

3.2.3 MICROLEVELS
We will not list grammatical items we think a necessary part of the syllabus, which follow simply the internal organization of any classical commercially available grammar book. Rather, we concentrated our work on contrastively relevant grammatical items for Italian students - in particular of English as L2. Contrastive difficulties have all been turned into grading modalities for different types of drills both written and oral.

4. LANGUAGE ACTIVITIES AND DIDACTIC MODULES
Activities and Modules of SLIM are organized as follows:
a. audiovisual teaching units (watching and listening); b. audio-speaking practice (phonetics and prosody) c. writing skills (phonotactics by dictation); d. remedial linguistic activities (grammar-syntax-semantics); e. advanced exercises (understanding, role-taking, autonomous writing); f. self-assessment and testing.

All these components have been implemented on a Macintosh PowerPC and has the LKD on a separate CD-ROM. Students may access it on a fully computerized laboratory fully equipped for multimedia modality in audio-active-comparative booths. Each student executes his activities by means of a headset for his speaking-listening tasks.

We shall now describe in some detail Phonetic and Prosodic Activities. Phonetic exercises focus onto phonemes that cause users the most difficulty. Phonemes have been divided up into consonants and vowels, and graded for difficulty. We created a hypertext which accesses each phoneme and helps the student in difficulty. Each phoneme is accompanied by a video clip with the front vision of a native speaker’s mouth while pronouncing it. Users’ phonetical problems may be detected by the AT in Guided Modality, or they may be indicated directly by the student by clicking on the Vocoidal Trapezoid (see Canepari 1983) which has been divided up into areas of phonemes which share common features; else, they can type in the word that caused them problems and automatically get the same information. Oral phonetic and prosodic activities include the following:
1. Exercises on contrastive phonemes
These exercises are aimed at developing users' confidence in different types of phonemes existing in the various languages through a contrastive analysis of Italian and the foreign language which they are learning. Exercises are based on a dictionary mapping that considers the difficulty level of the phonemes of the foreign language in relation to Italian phonemes. Phonemes are therefore divided into classes of different difficulty levels. These exercises treat the various phonemes in sequence of increasing difficulty; thus, they will start with phonemes that present less problems for the Italian speaker, and will end with the most difficult ones. The exercises that have been proposed are of three kinds: i. the first one focuses on the perception and correct identification of a given phoneme from a set of four phones chosen at random by the computer from amongst a cluster of phonemes belonging to an easily confusable set, and according to a given scale of difficulty; ii. the second one requires the student to identify the tonic phoneme of the word that is proposed again from a set of four; iii. the third one relates to the difficulty involved in uttering the phonemes of a whole single word --i.e., the difficulty resulting from the sum of all the difficult aspects of each phoneme that are composed within the proposed word. In every exercise the system proposes words randomly, selecting them according to their levels of difficulty. Users can decide for themselves to move on to the subsequent level of difficulty.

2. Minimal Pairs Perception and Recognition
The system proposes minimal pairs in two columns which the user may listen separately, with British English native speakers' pronunciation, but also with the synthetic speech available on PowerPC. The system then requires the user to decide in a short time whether two words contain the same stressed vocalic phoneme or whether the two words have different stressed phonemes. In another exercise, students are asked to pronounce each pair of words in a sequence, and the system recognizes the minimal pairs users are pronouncing. Subsequently, the system transcribes the users' performance and checks its correctness.

3. Exercise on word-stress
This exercise as the one on intonation presented here below is based on a program “Prosodics” created at the Laboratory of Computational Linguistics of the University of Venice with the contribution of research fellows from the University of Iasi in Romania. The aim of this exercise is to make speakers of L1 feel more confident with the peculiar characteristics of word-stress in the target language. In particular, the exercise draws users' attention towards the position of word-stress: the longer the word, the more difficult it is to guess the right position of stress. Thus, the system proposes words (not shorter than three syllables) and users pronounce them, using stress in the right position. The system evaluates the correctness of users' oral performance by comparing the student's with the master's performance. Both at word and utterance level, Rhythm, the position of stress and the overall intonational curve is assessed and feedback provided. (see Delmonte et al. 1995c)

4. Exercise on intonation
Among the advanced activities this exercise plays an important role in improving the prosodic aspects of oral production. In particular, it deals with intonation and directs learners' attention to the various intonation characteristics used in sentences with different communicative functions. Users are asked to produce the proposed sentences with an intonation as close as possible to the master's. The system then compares users' performance with the master's.

5. Choose an answer
This is one of the most interesting activities because it joins together speech recognition, the ability of choice at a text level and oral production, in a pleasant and stimulating way. Users listen to a question that the system selects among those available in the database. Users listen to the question twice and then select from three answers that appear on the screen, drawn from the LKD. Users have to select the most appropriate answer for the kind of question they have just heard, within the time given, and, once they make their choice, they produce it orally. The system activates the speech recognition mechanism that can give different responses. If users' utterance is not clear and correct, the speech recognition module informs users and invites them to try again. If users' performance is qualitatively good but the answer is incorrect, users are asked to listen to the question again and choose the right answer. Eventually, if users select the correct choice and produce it correctly, the system will respond to the good performance and users will be able to move to the other questions.

6. Role-plays
This activity has the objective of testing students' proficiency in the communicative functions of L2. The system has access to all dialogues and to each utterance thereof via the communicative function it expresses. Students will have to listen to the complete clip paying great attention to the particular role that each will have to act out. On a later occasion, each will listen to the clip without the utterances which they themselves will have to make. They will have to be ready to interact with the text by correctly pronouncing the missing expressions. To make the activity more authentic, learners will only be given enough time to utter the correct expressions as in a normal dialogue. Speech recognition will allow the computer to give immediate feedback to the student. When the role-play has been completed, learners will be allowed to compare their work with the original. In addition,
users will also be able to activate the automatic prosodic supervisor and through this it will be possible to evaluate the correct rhythm and correct intonation pattern, as well as the position of sentence accent.

7. Dictation and other oral exercises

5. ASSESSMENT, EVALUATION AND TESTING

Generally speaking, assessment in self-instructional courses is problematic but very important. Self-assessment can be used for appropriate testing purposes - to provide feedback information, diagnostic testing, and placement testing. Within learner-centred self-instruction, or self-directed learning, self-assessment is a necessary part. Decisions about whether to go on to the next item, exercise or unit, decisions concerned with the allocation of time to various skills, decisions concerned with the need of remedial work, are all based on feedback from informal and formal assessment. This concept then is central both to the learners’ personality and to the kind of courseware we are building. We consider it important as an educational goal in its own right, and training learners in this is beneficial to learning.

In fact, language learners regularly engage in self-assessment as part of their learning. They make exercises and check, by whatever means available, whether their responses are correct or not. They check the computer’s comprehension of their spoken language, and adjust it when necessary. To check oral production, the computer is equipped with the appropriate speech recognition system which is part of the PlainTalk™© system by Apple. Self-monitoring is also part of the course to mimic audio-active comparison while listening and watching to video clips, learners are required to check their performance against the model. To improve the ability to self-monitoring, all oral exercises have some form of visual feedback.

In a language like English, the ability to perform a complete phoneme-to-grapheme translation in L2 is severely undermined by its phonotactics which is full of exception and requires a lot of exercise to couple understanding and orthographic abilities. As for written language skills the number of assessment tools is fairly extended and are based essentially on the knowledge the computer has of every single linguistic item considered in a given task. For instance, in case the AT is assessing the learners’ achievements in grammatical knowledge, it accesses the LKD where each item may correspond either to a word-form, or a syntactic phrase for syntactic tests; or still to an utterance for context-based pragmatic and communicative function tests.

The LKD is the foundation for all drills construction, and thus it constitutes the basis of all self-assessment activities as well as the AT’s ones. In particular, the AT may create an infinite number of drills automatically since it has been given an internal pedagogical and linguistic set of criteria on the basis of which it may choose at random from the LKD the items relevant and adequate for any given linguistic task.

The AT has also been equipped with a number of tools that enable it to check and spot mistakes and errors whenever they are made by the learner, and keep record of them. Errors may be noted in both oral and written activities, and will be simply notified to the student in Free Modality or communicated by the AT when working in Guided Modality.

In all cases, learners will be informed about the error, the kind of error they produced, the possible reason why they made that kind of error: as aside-effect, they will be directed to carry out some linguistic activity appropriate to help remedy that problem or else the grammar section on that item will be shown. The same will happen with phonetic problems: in case the performance scores too low, the phonetics hypertext will be called and presented to the student at the appropriate item.

After being administered a placement test the student is assigned to a Macrolevel. Suppose our student is placed in Macrolevel 1, the AT will try to individuate the Microlevel from the six available according to constraints imposed on each such level. Objectivizing such constraints in the linguistic materials presented to the student while working with SLIM requires a further important step: assigning scores.

Scores are assigned for each main activity at every level of linguistic description: from phoneme to utterance level. In particular phonemes are graded according to contrastivity criteria as well as to perceptual discriminative ones. Words receive a cumulative score according to their inherent phonetic grade of difficulty. Words are also addressed at grammatical level in order to be assigned scores: functional words receive a higher score than content words, and amongst these irregular ones have a still higher score. Structural scoring is computed at utterance level and takes into account intrinsic syntactic complexity in terms of number of constituents, number of embeddings, whether its constituents are argument or adjunct. All the low level scoring adds up to the functional scoring already assigned at utterance level ending up with a final computation which is evaluated and weighted by the AT.

We are also working at a Parser which has a high linguistic coverage of both Italian and English in order to recover error information and thus interact with students’ performance in free writing activities.
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Multimedia: How INTER - How ACTIVE: Do We Really Know? Concern about ‘Positions’ and Priorities for Action

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Abstract: This paper attempts to identify current patterns and trends in the deployment of research and development activities in the application of computational media. Overviews are provided of activities under the EU-DELTA programme 1991-95 and of the papers submitted to three ED-MEDIA conferences, 1993-95. The relative impact of Instructionist and Constructionist approaches is discussed and it is argued that while each may have its domain of validity, there is a significant under-emphasis on pedagogical evaluation and a consequent difficulty in relation to attempts to achieve implementations of a significant scale within educational institutions.

Introduction

Access to ever more powerful technology at a cost which is declining steadily in real terms may be welcome news for educators. However, there is a sense of unfinished business about much of what has transpired in recent years and a particular lag in integrating/reflecting experiences with advanced technologies in the wider framework of pedagogic thinking. What is heralded as ‘Interactive’ may, in many cases, be neither ‘inter’ nor ‘active’ and there is arguably too little emphasis on methodologies of investigation.

There are a number of issues and they are outlined below. Symptomatic of the issues is an apparent inability or unwillingness on the part of the ‘educational’ community to grapple with some difficult questions and a use of terminology which is so varied as to convey an impression of a profound sense of paradigmatic uncertainty. The issues outlined are an interpretation by this author, based on separate involvement over a number of years both as a project manager, and project evaluator under EU-programmes, e.g. DELTA, COMETT and TELEMATICS, which seek to stimulate innovation by providing funding for research, pilot and actual applications developments. An overview has also been undertaken of the proceedings of all three ED-MEDIA conferences to date, to discern ‘positions’ of authors and evolutionary trends in the nature of papers presented.

Issues

Unlike the unprecedented cultural development in 17th century Holland, described in Simon Schama’s book, the ‘embarrassment of riches’ in this technological age has yet to provide many exemplars or a clear direction for pedagogical advance. Consider the following seven issues:

1. Credibility problems? Persons who have invested significantly, personally and professionally in the design and development of multimedia resources or courseware, generally do not use such media in the context of their own learning or development. Clearly effects may be “more pronounced for the people involved in producing the materials rather than students using the system” (McKnight et al. 1991)
2. The seeming futility of trying to reconcile ‘teaching’ and ‘learning’ approaches; “...competing paradigms cannot be held to be complementary; if they exist at all it is because they contradict...” (Lane 1995 p 64).
3. Widely varying use of terminology this is discussed below
4. Failure to ground or adequately discuss developments in the context of theories relevant to learning, however eclectic the mix. This is discussed at length by Doll, who argues that “There is a need to study other disciplines and to abstract, metaphorically not literally, those ideas and ideals which have pedagogical potential.” (Doll 1993 p.13)
5. The seemingly relentless ‘bandwagon’ and the constant technology push. Much of what is presented is reportage on experimental or pilot developments; all to rarely do we hear about the follow-up; one wonders if there is any in many cases.
6. Scaling: One of the most significant challenges is the scaling up of strategies and applications that have been implemented and evaluated successfully with smaller groups. The body of reported experience in this regard is all too limited.

7. Evaluation with ‘real’ students. Much of what passes as evaluation is limited in both scope and scale. ‘Users’ are often small experimental or pilot groups and the relationship of ‘experimenter’ to ‘subject’ may confound results, which in any case could not be reasonably generalised to a wider body of users in a ‘real-world’ situation.

One European Perspective

Commentary on the status of and issues surrounding the implementation of what are referred to as ‘ALT: Advanced Learning Technologies’ in 14 European countries echoes the above issues (Lajus, 1995). There is a consensus that the ‘technology’ issues will ultimately be resolved in the wider business/commercial sector, but yet it seems surprising that the Education & Training ‘community’ has to date spent so little time focusing on pedagogical debate. The final report of the EU-DELTA programme (EU R&D programme on Telematics for Flexible and Distance Learning), highlights a number of priorities for future action, including the capture and dissemination of ‘useful experiences’, particularly those drawn from larger-scale projects and a need for a greater pedagogical emphasis and an understanding of ‘new paradigms for learning’ (Bates, 1995 pp.39-41). In the period 1991-95, a total of 43 projects and studies were undertaken under the DELTA programme and Fig. 1 provides an approach to how they may be categorised. While this is one ‘snapshot’, many educational, professional and commercial organisations have been involved in the work carried out under this programme and the distribution below is a reasonable indicator of the current state of play. While at first glance the distribution seems quite well balanced, with an encouraging 14% of projects or studies addressing pedagogical issues, including evaluation, it is significant to note that the more ‘technology-led’ areas, including technical, design/authoring and prototype development projects, between them accounted for in excess of 53% of the total.

An Alternative Perspective: ED-MEDIA 1993-95

Since its inception in 1993, the ED-MEDIA conference has provided a world forum for debate and it would be reasonable to assume that an alternative ‘snapshot’, based on consideration of the pattern of papers submitted to each conference, would provide a useful indication of evolving trends. Not all papers specifically discuss what may be termed ‘applications’. A total of 293 papers (invited and full papers) have been presented over the first three years of this event. An initial attempt at categorisation of papers with an ‘applications’ focus suggests eight categories:

- Resources: Multimedia Resources, CD-ROM or Distributed
- Activity-based Resources: Simulations, modelling, case-based, gaming
- Tools & Templates: Content-free applications, worldware
- Didactic Courseware: Highly structured and sequenced resources
- Intelligent Tutoring Systems: Applications of Artificial Intelligence, Modelling of Student
- Automated Testing: Systems that automate student testing, with varying degrees of feedback
- Communications: Email and electronic/videoconferencing for synchronous or asynchronous communications
- Collaborative Working Environments: CSCW and other groupware applications that facilitate peer/group working
Looked at over the three years, the origins of papers according to the above categorisation, are shown in Fig. 2.

No major trends are revealed in this figure, but it is interesting to note relative increases in 1995 in submissions under ‘Activity-based’, ‘Didactic’ and ‘Communications’, with a proportional decline in interest ‘Resource-based’ applications. Not shown, but evident from the underlying analysis, is a significant shift towards distributed multimedia resources in 1995, not surprising in the context of WWW developments.

A disturbing picture emerges when the pattern for what might be referred to as ‘minority’ papers is examined. This is shown in Fig 3. These include papers which are of a more general nature, including overviews, theoretical perspectives, discussions of design and papers of a strictly technical nature. Also included are papers that make specific reference to evaluation with ‘real’ users. Given the overall volume of papers that describe one or more of the applications categories (an estimated 42% of all papers), the proportion that give serious attention to evaluation is, from an educational perspective, embarrassingly low. It also appears to be in decline, giving some basis to the ‘bandwagon’ argument; in the race to keep pace with the technology we would seem to be losing sight of the opportunity to derive real or lasting benefit from experiences with technologies that have attained relative maturity. There also appears to be a trend towards decline in interest, on an already low base, in papers dealing with overviews or design issues and a corresponding rise in the number of papers of a purely technical nature.

‘Teaching’ and ‘Learning’ Approaches

Objectivist and Constructivist paradigms have been hotly debated for quite some time. Duffy and Jonassen (1992) provide a comprehensive overview of this debate. Lane (1995) takes the view that in the final analysis, one’s philosophical position is really a personal, ethical choice: “The choice is governed by ethics...the theories thereafter differ only on the basis of the language used to describe the observed world.” Whatever about the underlying philosophical positions, approaches to specific situations can be clearly differentiated as ‘instructionist’ or ‘constructionist’. The lexicon of instructionist or constructionist approaches is markedly different, see Table 1 below. The lists are not infallible, but in the reading of any publication, usage of terminology may provide a first indication of the ‘mindset’ of the author.
Both approaches may have their respective domains of validity and in this context Clark’s argument (Clark 1983, 1994) that ‘method’ is the important ingredient in learning with media deserves careful consideration. It serves to highlight the importance of clarifying underlying theories of learning, which provide the ultimate rationale for methods, media realisations and implementation scenarios. This theme is also developed from from a ‘quality’ perspective by Pennington and O’Neil (1994) who are emphatic in their assertion that there is a ”..pressing need for practitioners to make explicit their philosophies, policies and practices about, and for, teaching.”(p.13). We do need to know where we stand, even if it is only to agree to differ!

Instructionist approaches to the use of technology may, rightly or wrongly, be regarded as attempting to secure cost or learning efficiencies, perhaps less glamourous, but more achievable in practical terms than constructionist approaches, which are generally associated with a shift in thinking about curriculum from information processing models towards models which emphasise independent learning, problem solving skills and skills in identifying and synthesising meaning from multiple and extensive information sources (e.g. The 4Rs: Rich, Recursive, Relational and Rigorous - Doll, 1993). Many existing systems are assessment driven and rooted in instructionist practice and there are unquestionably real difficulties in implementing constructionist approaches on any significant scale, particularly when it comes to devising appropriate assessment strategies. Clearly, instructionism and constructionism will be with us for some time to come, for pragmatic as much as for principled reasons. Arguably, the constructivist may not have too much difficulty in deploying either instructionist or constructionist approaches, but the objectivist is likely to have a predisposition towards instructionist approaches.

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Insofar as it has been possible to make a value judgement as to the disposition of the authors, an analysis of approaches is presented in Fig. 4. In a number of cases it was not possible to make such judgement.

As might be expected, the areas where constructionist approaches are dominant are those where the methodology requires a high degree of activity, through the use of tools, simulations and collaborative working environments. Referring back to Fig.2, it can also be seen that applications of this kind are in the minority, evidence perhaps of the complexity and design difficulty inherent in such methodologies.
A high proportion of applications dealing with multimedia resources are instructionist in approach, a trend which
was particularly noticeable in 1995. This may seem surprising, but with the advent of WWW, the debate has
shifted significantly to the use of ‘information servers’. The ‘quality’ of the learning experience for individual
students is receiving proportionally less attention; there is a real problem of unfinished business here. There is
little evidence that earlier pedagogical studies on the use of hypermedia resources (e.g. local or CD-ROM based)
are influencing strategies for the design or use of distributed resources or that studies of this kind are in general
receiving much attention at this time.
The overall pattern for the three years is shown in Fig. 5. The volume of papers with a constructionist bias has
remained stable at around 20%. However, there has been a sharp increase in 1995 in papers adopting an
instructionist approach.

Discussion

The focus of research on media/learning technologies and the level of activity in particular areas shifts
constantly. The ‘snapshots’ provide one perspective on where the balance lies at this point in time.

It is clear that, as a community, educators are having some difficulty in grasping the nettle in vital areas. In
consequence, we may be seeing a retreat into areas of activity and research which serve the important function of
keeping us abreast of the rapid advance of technology, but which do little to enhance our understanding or
repertoire of strategies for deploying technologies which have achieved relative maturity.

Innovation and Scaling

Innovation by definition involves organisational change and the typical combination of large class sizes and
rigid, long established procedures makes it extremely difficult to implement technology-reliant strategies, novel
or otherwise, on any significant scale. A natural corollary of this is the fact that many projects are designed to
find ways of modifying or enhancing existing instructionist strategies. Improved presentations techniques, access
to information and resources and the use of electronic forms of communications are clearly useful, but it must be
recognised that they ultimately reinforce traditional approaches.

Curricular Reform

A key question must be the role of technologies as agents of radical curricular reform, particularly in the
facilitation of constructionist environments for learning and assessment. Unfortunately, too few researchers
appear to be addressing this issue. Kozma (1991) discusses the concept of ‘distributed cognition’, the use of
computing/multimedia devices to share the cognitive load associated with tasks that involve active engagement
with complex subject matter. The use of devices in this way is in marked contrast to their use fundamentally as
‘information servers’; however sophisticated. In the intervening period, there has not been significant progress
on the position outlined in 1991 that “...little research (particularly process research) has been done on learning
with multimedia environments” (Kozma 1991 p. 199).

Evaluation

The apparently low level of priority given to evaluation with ‘real’ users must give rise to concern. Rigorous,
comprehensive investigation of both instructionist and constructionist strategies for deployment of computational
media must necessarily precede wider adoption and a resolution of the scaling issue. Methods used for
evaluation of pilot implementations are frequently limited by the relatively small scale of the particular pilot.
Complex socio-cultural currents characterise any learning situation and methodologies of investigation need to reflect this. Knussen et al. (1991) provide a useful framework for the evaluation of hypermedia environments, in which they propose a naturalistic approach including observation, self-report measures, interviews, automated measures and psychometric tests. A comprehensive framework for designing naturalistic investigations is also provided in Lincoln & Guba (1985).

Conclusions and Priorities for Action

The overviews provided by the ‘snapshots’ in this paper suggest that there should be cause for concern with regard to the recent direction and focus of research on media and technologies. There is a growing recognition of the need to scale down the ‘technology-led’ focus, but to date this has not occurred. There are, however, positive developments including e.g.

- TLTPs (Teaching and Learning Technology Projects) (UK Universities)
- CTIs (Computers in Teaching Initiatives) (UK Universities)
- Euro Study Centre Network (Sponsored by member institutions of the European Open University Network)
- TLTRs (Teaching and Learning Technology Roundtables) (US Universities)

Initiatives of this kind provide a forum for action with stable as well as emerging technologies, an opportunity to develop and deploy courseware and other resources and a forum for co-operation in evaluation and discussion. However, since activities under these and other programmes require funding, priorities for action can best be determined through an enlightened policy by funding agencies in defining requirements. Priorities should include:

- Significant allocation of resources to projects that involve implementation on a significant scale of technologies that have attained relative maturity
- Requirement for comprehensive evaluation of project outcomes and proportional allocation of funding within projects for this
- Recognition of differences in instructionist and constructionist approaches and provision of resources to support the development of a body of design/implementation expertise in the appropriate deployment of either approach

References

A Teaching and Learning Framework for Images for Teaching Education Project

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Abstract: The University of Exeter heads a consortium which has developed multimedia resources primarily for initial teacher education. Amongst a range of resources produced are Critical Encounters in Secondary Education, which deals with critical incidents in the classroom and how to deal with them; Multimedia in the Learning Environment, which deals with both the nature of multimedia and how it may be used in support of a range of approaches to teaching and learning; and English Chalklands which deals with interpretational and judgmental responses to landscape. The resources are described and the teaching and learning framework which has been developed to guide their use is discussed.

Introduction

The Images for Teaching Education Project is funded by the Higher Education Funding Council for England, the Scottish Higher Education Funding Council, the Higher Education Funding Council for Wales and the Department of Education Northern Ireland under Phase II of their Teaching and Learning Technology Programme. The Project is based at the University of Exeter. Collaborative work on the development of multimedia resources, and a framework for their educational use, has involved staff from the University of Reading, Sheffield Hallam University and the University of Northumbria at Newcastle. A number of other universities are supporting the project through contributions of materials and advice and providing facilities for trialing.

Amongst a range of multimedia resources produced are: Critical Encounters in Secondary Education developed at the University of Exeter, Multimedia in the Learning Environment developed at Sheffield Hallam University and English Chalklands developed at the University of Reading. The resources have been produced with an emphasis on the use of images to support teaching and learning. They are aimed primarily at student teachers, but other major users will be university tutors and co-tutors (teachers overseeing the work of students in schools, ‘mentors’ in some institutions), staff in schools and providers of in-service education. English Chalklands may also be used by undergraduates following courses in geography, archaeology, agriculture and environmental education and professionals on vocational courses which address policy making and management in three areas of rural land-use: agriculture, recreation and conservation.

This paper describes the resources and the teaching and learning framework, which is common to all titles, and was developed in response to the need to integrate the resources into an appropriate supported self-study framework.

Critical Encounters in Secondary Education
Critical Encounters consists of a videodisc, videotape and barcoded support materials. It is concerned with critical incidents in the classroom and how to deal with them. Whilst it is impossible to completely recreate reality outside the classroom, image-based interactive technologies provide surrogate classroom experiences. These surrogate experiences may be used to stimulate focused interaction and discussion between tutors and student teachers, as well as providing resources which cater for a more flexible approach to learning.

The approach adopted in Critical Encounters is both complementary and supplementary to that offered in many classroom management courses. There will be occasions when a critical incident occurs in the classroom. Such incidents can, and do, occur regardless of the experience of the teacher. Whilst it is essential to adopt good working practices which minimise the possibility of critical incidents occurring, they can never be avoided altogether. Consequently, student teachers need guidance on how to deal with them. A number of critical incidents have been captured on video and laid down on a videodisc which makes them accessible in a variety of ways.

Multimedia in the Learning Environment

Multimedia in the Learning Environment consists of a videodisc, videotape and barcoded support materials. It is concerned with both the nature of multimedia and how multimedia may be used in support of a range of approaches to teaching and learning. A video montage has been produced which deals with the learning environment and the place of multimedia within it.

The video montage is made up of scenes of teachers and students working in different learning environments, notably classrooms and resource centres. Like Critical Encounters, the video montage is laid down on a videodisc. This is using multimedia as a means of studying multimedia. In particular, the concern is with multimedia in relation to: the infrastructure of the learning environment; the management of the learning environment; teaching and learning styles; support for staff and students; and integration and implementation within the curriculum.

Multimedia in the Learning Environment promotes the development of skills to give student teachers the confidence to effectively exploit relevant information resources and services. The resource will reflect both the school environment that student teachers are about to enter and their present learning environment within higher education. The resource has been designed to: stimulate learning and discussion; provide a detailed reference source of examples; and provide a diagnostic environment to support the development of skills.

English Chalklands

In contrast to Critical Encounters and Multimedia in the Learning Environment, which are concerned with resourcing and managing learning, English Chalklands has been developed to support subject-based work. The resource consists of a photo CD portfolio (100 images with commentary) and support material presented on computer disc which includes a case study and a theoretical framework for interpreting landscape.

The resource deals with the North Wessex Downs, a chalkland region in central southern England. It provides opportunities for exploring technological, socio-economic and aesthetic perspectives on landscape as well as the more usual geographical content. The main types of rural land-use, rural vernacular architecture and some of the principal prehistoric sites in the region are illustrated.

The Teaching and Learning Framework

Ausubel is reputed to have said: "If I had to reduce all of educational psychology to just one principle, I would say this: the most important single factor influencing learning is what the reader already knows. Ascertain this and teach him accordingly" [Head 1982].

The adoption of multimedia in education is likely to be successful only if it is integrated into a teaching and learning framework which takes account of users' prior experiences and if it is designed in such a way that it can be adapted to meet specific agendas [Laurillard 1993]. The following general considerations about prior knowledge have been adapted from Osborne and Wittrock [1985] and extended to take account of multimedia:
• all knowledge is constructed by the student as he or she interacts with the environment and tries to make sense of it;
• students will hold views and possess knowledge based on prior experience;
• each student will have prior experience which is unique although there may be some generalisable things that can be said about it;
• students tend to generate perceptions and meanings which are consistent with their prior experience;
• the views held/knowledge possessed by students is likely to be different from that held/possessed by tutors;
• students' views can remain uninfluenced or be influenced, sometimes in unanticipated ways, by teaching or exposure to multimedia resources;
• all knowledge is acquired not by the internalisation of some outside given meaning but by construction from within, of appropriate representations and interpretations.

Where learning is expected, but does not occur, this may be because:
• students are satisfied with their current explanations of phenomena so that there can be little or no motivation to change existing ideas;
• students often generate links and construct meanings from sensory data to fit in with their current ideas;
• it is easy for students not to test their constructions against other ideas;
• major reconstructions, where necessary, can be resisted by the students for a range of reasons.

In order to address these matters, we need to create situations which:
• require students to invoke their own frameworks in order to interpret the matters set out above;
• require students to verbally and pictorially describe their ideas;
• provide students with the means to explore different explanations, although this may create cognitive conflict;
• provide students with information and support structures which help them to resolve cognitive conflict and accommodate new ideas.

These considerations have guided the development of the teaching and learning framework for the Images in Teaching Education Project. They are particularly important given the multiplicity of uses to which the materials are likely to be put. At one extreme, the materials will be used on an ‘open access’ basis, at the other, they will be 'embedded' in different course structures in different institutions and used with and without the mediation of a tutor.

In the embedded use, course goals and educational aims will define the context in which the materials will be used. Learning objectives, derived from the course goals, and educational aims will define the individual and specific requirements that users have of the materials.

In the embedded use, Critical Encounters and Multimedia in the Learning Environment will be accessed through barcoded courseware. This approach, which has been used successfully at Exeter and elsewhere for some years, [Wright and Dillon 1990; Wright and Tearle 1990] has the following advantages:
• the replay facility of barcoding allows users to review visual sequences from a carefully thought out perspective and to watch them a second or third time with a specific purpose in mind. They are able to look at, and reconsider, a specific set of images noticed during a first viewing or to which their attention was drawn during discussion;
• use of the freeze frame facility to study a specific still image. The stability of a videodisc still frame provides excellent picture quality. The user can therefore concentrate on the picture content, and not be distracted by poor picture quality;
• the paper-based barcode access makes it easy to move around the disc content in order to review, discuss, compare and contrast relevant material from different visual sequences. This is not always possible when controlling a videodisc through computer software when user access to sequences may be pre-determined by software design. A facility which allows a user to look through a complete set of sequences on a single page enables faster and more frequent comparisons to be made.

Critical Encounters has been designed to maximise these advantages and at the same time address the considerations about prior knowledge set out above. Each incident incorporates about one minute viewing time and consists of an 'introduction', a 'stem', and a number of 'outcomes'. The stem plays through the incident up to the critical point. Some incidents have associated with them a commentary which raises points for discussion relating to the human and environmental elements of the situation.

'Analysis' of the stem is encouraged. The analysis may be of: behaviour, for example, conformist, confrontational, indifferent; and/or the environment, for example, room layout, organisation, management,
approaches to teaching and learning. The analysis raises a number of 'issues' about which 'judgements' are made, for example empathy between student and teacher, appropriate/inappropriate practice.

There are many different ways in which each incident could be handled, so for each several different short 'outcomes' are presented, each reflecting different practice. These are scripted where appropriate to pick up the issues and judgements which may be raised through the analysis of the stem. This approach is designed to promote discussion rather than invite student teachers to label practice 'good' or 'bad'.

At each stage in this model for the use of Critical Encounters, there is the potential for diagnostic use of the images, either in open format or in conjunction with some analytical text, to address users prior experiences and personal agendas. The following are some of the ways in which this might be achieved:

- through a tutor working with a group of student teachers using certain 'trigger' sequences, followed by small groups of student teachers accessing the same and additional sequences in directed study time;
- by student teachers viewing the video sequences on a school site with appropriate courseware and support from a practising teacher mentor;
- by student teachers calling up clips of video stored on computer, either directly or from a distant source to use in presentations to fellow student teachers, university tutors or co-tutors.

The Multimedia in the Learning Environment materials have been designed to accommodate an embedded use based around course goals, educational aims and learning objectives. For these materials, however, the precise needs of student teachers, university tutors, co-tutors and other potential users are not so easy to anticipate. The video montage is divided into 34 short sequences organised into 6 chapters: technology, applications, learning activities, learning issues, management issues and learner interaction. The sequences are accompanied by a commentary interspersed with teacher and learner comments that raise issues. Three main modes of use are envisaged, each with its own support documentation:

- an open, quick access route to the video sequences, designed to support tutor-led discussion and the single user and to cater for situations where delivery platforms are provided as stand alone facilities in libraries and resources centres;
- a guided tour which provides more information about each sequence and allows the user to make an informed choice based on individual needs;
- focused routes which address specific needs. Five key needs are identified and relevant issues and questions are raised. Each route combines video sequences with issues to consider and directs the user to other video sequences that may be relevant. These routes are designed to support tutor led sessions and open and distance learning where an individual user or small group can work through a route in preparation for further work with a tutor.

In English Chalklands, the commentary is used as a vehicle for posing questions about the images. 'Interpretational' questions help users establish what they know, or need to know about the landscapes depicted; 'judgmental' questions elicit a response from the user, often a very personal one. The overall meaning that an image holds for the user will be a synthesis of the interpretational and the judgmental. The resource is 'flexible' in the broadest sense in that it addresses multiple and diverse user groups and may be used in a number of different modes. The following are some of the ways in which it may be used:

- in its entirety as a self-contained, supported self-study module;
- as a means of focusing on the case study or any of the sections within it;
- by selecting images to set an agenda for researching the landscape history of any other defined region;
- by selecting images to explore the assumptions on which the theoretical framework is based;
- by a tutor working with a group of students using images to illustrate certain themes, followed by individuals or small groups accessing the same and additional images and text in directed study time;
- by students selecting images to use in presentations or seminars;
- by students 'negotiating' a route through the materials based on a series of questions and their responses to them;
- by tutors 'channelling' students through the materials based on needs identified through responses to key questions;
- by tutors or students selecting images as a stimulus for research, analysis, problem solving, simulation, argument, debate, reporting, exposition, and evaluation.

With Critical Encounters and English Chalklands, the prior experiences and expectations of the different user groups can be established partially through their responses to the images themselves [Dillon and Gayford 1995]. With Multimedia in the Learning Environment it will be necessary to adopt different strategies to elicit this information. One possibility, currently under investigation, is a 'diagnostic' section involving the use of text-based questionnaires. There are some well tried instruments to determine the extent to which users agree or
agree with particular statements. Responses to clusters of statements may be used as a means of routing users into appropriate sections of the materials. The routing may involve exercises which explore further the users attitudes or stances with respect to a particular situation.

The use of diagnostic strategies implies some form of tracking of users progress with, and experiences of, the materials so that their raised awareness and knowledge and skills acquisition can be monitored and their personal agendas and expectations reviewed. There are implications for using multimedia for trying to achieve this [Fleming 1993]. The most obvious pitfall is that technologies often impose their own ways of doing things. In overcoming these problems, it is important to take account of what we already know about individualised learning, group dynamics in collaborative learning, and the behavioural characteristics of students using multimedia. These matters are fundamental to the project. The development of a teaching and learning framework simultaneously with the materials may prove to be an important step in finding new ways to integrate multimedia into teacher education.

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References


Simulations - New 'Worlds' for Learning?

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Abstract: The proliferation of increasingly sophisticated computer generated learning environments raises a number of philosophical and pedagogical issues. Many of the most interesting relate to the role of computer based simulations in educational contexts. From dynamic spreadsheets through 'microworlds' to virtual reality, the convenience and in many instances the seemingly intrinsic appeal of simulated environments exist in some tension alongside concerns regarding the relationship of the simulated to the 'real' and the possible consequences for human thought, learning and behaviour. This paper examines a selection of these issues in relation both to familiar educational computing environments and to others currently under development.

The proliferation of increasingly sophisticated computer generated learning environments raises a number of philosophical and pedagogical issues. Many of the most interesting relate to the role of computer based simulations in educational contexts. From dynamic spreadsheets through 'microworlds' to virtual reality, the convenience and in many instances the seemingly intrinsic appeal of simulated environments exist in some tension alongside concerns regarding the relationship of the simulated to the 'real', and the possible consequences for human thought, learning and behaviour. How do computer based simulations influence the processes by which we construct knowledge, and the content and form of the knowledge we construct?

There is a strong sense in which the representation involved in the translation of all types of information into digital form qualifies everything which appears on a computer screen to be regarded as a 'simulation'. In practical terms, however, there is a common understanding that computer based simulations involve the dynamic representations of process, incorporating to varying degrees the possibility of intervention, generally referred to as 'interactivity', on the part of the user.

In a rapidly broadening range of fields including scientific research, a wide variety of education and training situations, the dealings of multi-national corporations and of course entertainment, there is ready acceptance of the benefits of simulation over the 'real thing' [Benedikt 1991; Gelernter 1991; Rheingold 1991; Shapiro & McDonald 1992]. Simulations of varying degrees of verisimilitude are currently employed in a great diversity of situations where exposure to the 'real' might be considered too dangerous or too costly, or where the original events are inaccessible because of constraints of time, distance or size. Indeed it is increasingly assumed in many circles that everything worth knowing about can be modelled on a computer. Where the natural sciences were once taken as the ideal to which all knowledge should aspire, it is widely perceived that this role is being increasingly taken over by the computer, to the extent that it is common for computer simulations of scientific processes to use data which have been generated by other computer-based mathematical models rather than gathered from 'real' experiments. Taken to extremes we have Gelernter's [Gelernter 1991] conception of a 'mirror world' in which all 'relevant' aspects of community life are modelled on a computer as 'information' with which the individual may interact, with consequences which would take effect at a 'real world' level. The advantages in terms of access and enhanced capabilities for decision and action are portrayed by Gelernter as far outweighing those available through the normal dimensions of sensory experience and involvement. However, as Roszak [Roszak 1986] points out, electronic simulations lack the 'messiness' of life. They are generalisations made in accordance with value-judgments which may well ignore elements of a situation which contribute in a less than obvious way to the total picture. The significance, even the inclusion of particular elements, is a function not only of the judgment of the programmer, but also of the degree to which the information is amenable to being expressed in a computational format.

Nevertheless there are many areas in which new forms of computer generated representation can be of enormous benefit in making otherwise inaccessible information available to a wide range of people. The conjunction of the physical with the abstract is probably an important element in reframing many problems in such a way that solutions
become available. Visualisation, particularly of complex processes, can make them more accessible than can a linear description, and can also enable processes to be explored and even manipulated in a more intuitive way. Through modelling, computers can enable processes to be explored experimentally in a manner similar to word-processed text. It is possible to manipulate symbols then recapture the initial state and begin again, alternately hypothesising and testing in the manner of an engineer working with physical materials. Time can be both compressed and dilated. A special feature of the computer as a tool is its ability, through modelling and representation, to be of assistance not only in the achievement of immediate goals, but also in predicting and planning for future events and contingencies.

In educational settings, a particular advantage of computer based simulations is the degree to which modes of representation can be more closely specified, controlled and varied than in 'real life' situations. This aspect clearly resonates with more abstract conceptions of problem 'spaces' as encountered particularly in mathematical thinking, an important aspect of these being the degree to which selection of the parameters of the space concerned structures both the process of problem solution and the terms within which the solution itself can be conceived.

From another point of view, however, the degree to which both children and adults accept computer simulations of many types as being at least equivalent in value if not in some cases preferable to 'raw' experience raises some questions concerning the relationship of such environments to the 'real' world, particularly in relation to education. While a range of practical considerations support the usefulness of simulations in many contexts, the enthusiasm with which certain groups and individuals embrace the concept of substitute realities suggests the existence of motivations which go beyond the purely utilitarian. Recent work by Gelernter, for instance, suggests that human beings generally have a strong intellectual and emotional fascination with microcosms, which he relates to qualities such as the intensity of tightly focussed and encapsulated experience, and also to the will to dominate [Gelerntner 1991]. Knowledge encapsulated as computer based information is knowledge under control. As Heim [Heim 1991] writes, “The world rendered as pure information not only fascinates our eyes and minds, it captures our hearts. We feel augmented and empowered. Our hearts beat in the machines. This is Eros” (p. 61).

The relationship of this form of empowerment over an essentially symbolic environment to that which may be achieved in the real world is important in considering the role of simulations in many contexts, including education. These and many other writers, in addition to innumerable instances of observable practice, give credence to Rheingold's suggestion [Rheingold 1991] that "... reality is disappearing behind a screen ... reality itself might become a manufactured and metered commodity" (p. 17). Such attitudes are very much in keeping with postmodern thinking in regard to acceptance of the intrinsic 'reality' of simulations and copies, as opposed to granting them simply the status of representations.

A further factor which might well contribute to the high regard in which computer based simulations are currently held relates to the status of the computer as both a symbol and an embodiment of many of the attitudes and values prevalent in contemporary 'developed' cultures. While this adds weight in many quarters to belief in the primacy of computer based information, writers such as Streibel [Streibel 1988] have been quick to point out the degree to which this results in the privileging of certain types of information and modes of thinking above others. Any form of representation frames the content according to the constraints of the medium, thereby creating as well as reflecting relationships both within and between items and areas of information. At another level, digital encoding itself lacks the imitative qualities of analogue representations. In using computers we shape our ideas into quantitative, declarative or procedural terms according to the constraints of the program or of the programming language, the latter being a far less flexible medium of expression than the natural languages upon which our understandings are traditionally based.

Although not generally regarded as 'simulations' in the contemporary sense, a number of the issues which arise in considering the role of simulations in education can be explored through an examination of the concept of a 'microworld', first made popular in the 1980s in relation to Logo, and subject to renewed interest following the release of LCSIs Microworlds in 1993. As an image, the term clearly resonates strongly with current interests relating to the 'virtuality' of computing environments in general, and in particular to the role which computer generated simulations including virtual reality might play in educational contexts.

The term 'microworld', deriving initially from work in the area of artificial intelligence, is ubiquitous in early writings about Logo. It is generally used in two senses, firstly as a metaphor for the overall Logo environment [Tobias 1984], ("Logo is a microworld that is meant to be shared" (p. 95)), but more usually and for our purposes more interestingly in reference to programming environments defined within the larger context of Logo itself, which

Traditional Logo microworlds characteristically fostered the learning of procedures and principles rather than facts. They were practical environments or task domains so designed that available activities, while relating well to users' existing mental models, were predisposed to structure further understanding in particular directions.

Contrasting microworlds with CAI programs and making explicit an important aspect of the 'world' metaphor, Feurzeig [Feurzeig 1986] writes:

> Logo microworlds do not teach. Like real worlds they do not give away their secrets or explain themselves to passers by ... they simply exist and behave. .... In interactions with a Logo microworld a student strives to acquire or construct knowledge through active exploration and experiment (p. 44).

Such accounts of the nature and purposes of Logo microworlds establish clear connections with the most recent and sophisticated developments in computer based learning environments, not least of which is the characterisation of such environments as 'worlds'. As is the case with all metaphors, a range of understandings, some of which may not have been intended by its creators, are implicitly suggested by this image.

What entailments are in fact suggested or implied by the 'microworld' metaphor? A 'world' is generally understood to be an environment sufficient in itself. 'Microworld' carries with it the idea of diminution, but the level at which this can be assumed to operate is not clear. A microworld may be smaller than a 'world', but still self-sufficient as an environment. It may be understood to be a complete model of the real world, but in miniature, or alternatively the term 'micro' may imply a reduction in the number of constituent elements. A microworld may be conceived as a world constituted by a limited number of objects, relationships and characteristics. Indeed, from a constructivist point of view, it could be argued that any individual at a given point in time inhabits a 'microworld' in this sense, that is, a 'world' selected and constituted from the total available stimuli in accordance with his or her own particular stage of development, needs and metaphors. Consideration of these alternative interpretations is important in relation to all computer based simulations, given the fact that at some point those elements of a 'real' experience which are considered to be of relevance to the purposes of the simulation must be specifically selected.

In educational settings, while the arguments of the proponents of microworlds concerning the pedagogical effectiveness of selecting and isolating certain carefully chosen elements of reality in the interests of concept formation can be appreciated, the relationship of this type of learning to the construction of knowledge within a 'whole world' social, cultural, intellectual and practical context can be questioned. The Dreyfus brothers [Dreyfus & Dreyfus 1988], for instance, state quite uncompromisingly that, "Microworlds are not worlds, but isolated meaningless domains, and it has gradually become clear that there is no way they could be combined and extended to arrive at the world of everyday life" (p. 32). At issue here is the extent to which microworlds, isolated from a 'whole world' context, can properly be described as embodying 'meaning'. This type of objection might clearly be extended to cover a far wider range of computer based simulations.

A number of specific concerns relate to the learning which is understood to take place within such limited domains of experience. Gelernter [Gelernter 1991] suggests that, "For most people, the real world is just too big, sprawling, complicated, disorganized, intimidating, cold-and-wet or smoggy-and-smelly or expensive, unpredictable, inconvenient, dangerous, whatever" (p. 23). While this statement may be somewhat extreme, one of the widely acknowledged features of both microworlds and virtual reality is the diminution of danger, whether intellectual or physical. While this characteristic is purported to encourage intellectual 'risk taking' in students as in other users, the degree to which the concept of risk itself is cheapened within this context is of some concern. Risk, whether to one's physical, intellectual or emotional well-being, is an ever-present element of 'whole world' existence, and is closely bound to our choices of values and behaviour. As human beings in the 'real' world, our minds, bodies and emotions are inextricably entwined. Along with an awareness of risk, for instance, comes strong commitment to ideas and actions. The separating of the intellectual component of experience from other aspects, and the distancing of the individual from the more complex consequences of action, may be seen as not necessarily being in the student's best interests. While it is often suggested that simulations of various types provide 'safe' environment in which learners can explore and experiment, this very aspect removes an important element from the process of learning and developing within the wider social context.
The assumption that simulations provide more effective contexts than the real world for the construction of knowledge in specific domains depends on an understanding that such knowledge is readily transferable to an appropriate degree and in a functional form to other contexts. This in turn presumes the ability of the learner to distinguish between those aspects of the simulation which apply in the world outside, and those which do not. As Forman and Pufall [Forman & Pufall 1988] suggest in relation to children learning with Logo microworlds, "Constructive microworlds are manifestations of conceptual realities and not simulations of specific realities. As a consequence, general adaptations are achieved when children understand that microworlds are not to be treated as practical realities" (p. 249). In the case of Logo, for instance, we expect the learner to have acquired some usable understanding of geometric principles, rather than to deny the relationship of force and energy to movement in general. In fact it might be argued that an element of recognised 'unreality' within a microworld could be of benefit, in that the learner could build on intuitive knowledge gained from real-world experience while not being fully bound by it, thus potentially facilitating more flexible modes of thinking.

The spatial dimension implied by the term 'microworld' is more clearly realised in relation to developing concepts of cyberspace and virtual reality environments. The word 'cyberspace', originally coined by the novelist William Gibson [Gibson 1984], has become accepted terminology for the information 'spaces' created and mediated by computing technology, including 'virtual reality' applications. The link between this image and the concept of computer generated spaces as 'worlds' is made quite specifically by one of Gibson's characters [Gibson 1986]: "'Bobby, do you know what a metaphor is?' ... 'Okay,' Bobby said, getting the hang of it, 'then what's the matrix? If she's a deck, and Danbala's a program, what's cyberspace?' 'The world,' said Lucas" (pp. 162 - 163).

While it can be argued that cyberspace already exists in the form of global networks within which computer users can 'move' and interact at will, these are generally felt to be only the precursors of computer generated contexts in which representation will occur in a greatly increased range of forms, in some respects closely related to, but in others widely divergent from, 'reality' as we normally understand it. Within such environments as conceived both in the imagination of theorists and the actual achievements of researchers, the emphasis is on constructing a simulation of multi-dimensional space within which information of all sorts takes on quasi-physical forms. While in the most obvious sense cyberspace is a purely abstract environment, paradoxically the physical, at least as analogy, takes on increased importance, and in fact is regarded as one of the most important practical advantages of these environments, in that abstract information may perhaps be more easily comprehended and manipulated in some 'physical' form. From a practical point of view, such environments extend the advantages already inherent in simpler forms of simulation and modelling.

An important aspect of many advanced forms of simulation, in particular of virtual reality applications, is the digital encoding and representation of the human user or participant. Discussion of virtual reality environments generally places as much emphasis on 'interpersonal' interactions as on interactions with abstract concepts or data, in whatever form. The 'social' dimensions of the learning experience are not well represented in traditional simulations. They are a poor substitute for the 'real' world in this regard, which is one reason why educational programs which stimulate interaction between students outside the confines of the program itself have always been popular. The constitution of a persona within cyberspace, whether through language alone as in current electronic mail environments, or in some analog of a 'physical' manifestation raises fascinating questions related to the individual's sense of identity, including the perceived integrity and consistency of both body image and personality, traditionally perceived as qualities crucial to mental and emotional well-being. For instance, within virtual contexts, which aspect of individual manifestations will be regarded as 'the person' - a hand, an abstract shape, or some hitherto unimagined form? It would seem from the enthusiasm with which many users of electronic mail embrace the opportunity to overtly take control over their 'image' as verbally constructed, that the opportunity for enhanced control and creativity afforded by virtual reality environments would be welcomed by many individuals.

Anthropologists such as Tomas [Tomas 1991] are already engaging in speculation concerning the social and cultural alternatives which may be possible within this new social space. Of special interest to educators are the implications for the 'social' dimensions of knowledge construction. Further, as Novak [Novak 1991] argues, there may well be special advantages in human beings interacting on equal terms with other forms of information in the context of cyberspace. In such situations, he suggests, the usual privileging of the human point of view is overcome, and new relationships and insights become possible.

There are in fact many senses in which the capabilities and possibilities offered by the most technically sophisticated computer based environments push the boundaries of our thinking not simply in relation to technology as such, but to
far broader understandings of the world and of ourselves. As McFadden [McFadden 1991] writes, "Cyberspace is an exercise in the outer boundaries of our understanding of the world as information and is yet another way of tracking our old concerns about the 'human use of human beings' or the 'computer's use of human beings' " (p. 337).

These considerations certainly raise broad philosophical questions concerning the nature of reality, and indeed of the nature of 'nature' itself. Stone, [Stone 1991] for instance, argues that the category 'nature' is of value today as a strategy for maintaining boundaries, particularly where technologies, frequently of an ambiguous kind, are concerned (p. 100). The degree to which computer generated environments both now and in the future suggest a re-definition of 'reality' can be perceived as cause for concern. As one of Cadigan's [Cadigan 1991] characters complains, "I'm not afraid of life. I just don't know where it is any more" (p. 315). Similarly, from the pen of William Gibson [Gibson 1986], "the sinister thing about a simstim construct, really, was that it carried the suggestion that any environment might be unreal, that the windows of the shop-fronts she passed now with Andrea might be figments. Mirrors, someone had once said, were in some way essentially unwholesome; constructs were more so, she decided" (p. 197).

By contrast, and again in terms which indicate a focus broader than but not unrelated to educational concerns, Benedikt [Benedikt 1991] proposes a number of advantages which might accrue from the development of cyberspace as an environment for human action and interaction.

... it is proposed that the creation of cyberspace is not only a good, but necessary, and even inevitable step (1) toward providing the maximum number of individuals with the means of creativity, productivity, and control over the shapes of their lives within the new information and media environment, and (2) toward isolating and clarifying, by sheer contrast, the value of unmediated realities - such as the natural and built environment, and such as the human body (pp. 121 - 122).

In conclusion, conceptions of abstract spaces as sites for intellectual activity are certainly not new, and the notion that simulations, even of traditional types, constitute 'worlds' within which knowledge can be represented, explored and constructed is clearly of potential interest to educators at all levels. The extent to which it is helpful to attempt to simulate 'reality' in too many aspects is less evident. As a medium for cognitive activity, the computer affects both how and what we think and learn. While a number of features of the 'real' world which are thought to be relevant to the learning process can be replicated to a certain extent by computer programs, others cannot, and indeed it may well be that maintaining a distinction between the 'real' and the 'virtual' is an important aspect of the transfer of learning from computer based environments to the wider world. What, if any, might be the advantages in implementing a 'world' parallel to but able to be contrasted with our own, in which analogy and metaphor frame objects, actions and even personalities differently? This would be in keeping with existing notions of problem-solving spaces, where alternative representation is considered to be of benefit. Such considerations are of increasing importance in the light of the proliferation of increasingly sophisticated computer based environments being designed for purposes of education and training.

References


When is Software Both Valuable and Viable?

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Abstract: Support for learning typically takes four forms - facilities, tools and medi for directed instruction, learning by doing, real-time conversation, and time-delayed conversation. Historically many of us expected the computer or technology revolution to happen by augmenting or even replacing the faculty role in directed instruction through the widespread availability of curricular software. The use of technology is increasing but not in the way we expected. Instead “worldware” and “student editions” are being used to support all four functions. The reasons for the dominance of these types of software and hardware have more to do with issues of viability, not just value.

What Kinds Of Software Are Both Valuable and Viable?

Educom is an association of hundreds of colleges, universities and other organizations united in their commitment to the use of technology support learning and research in post-secondary education. Several years ago, a gradually growing group of us active in Educom’s program for Educational Uses of Information Technology (EUIT) began a research project: we wanted to know whether there were ANY families of software that were not only valuable but also viable.

We defined "value" to mean educational usefulness (as demonstrated by prizes won or evaluation results, for example.) We said that software was "viable" if it were used widely enough and for long enough so that all the parties to the software's development, distribution, and use could feel reasonably contented about the return from their individual investments. This Valuable Viable Software Project team was composed of academics, publishers, and hardware vendors who had volunteered to work together to solve a problem important to all of us. Dr. Paul Morris, Director of Computing and Communications at Tufts University in Massachusetts, soon became our leader.

Our twenty case studies of valuable viable software and resulting findings are laid out in detail in Morris et.al. (1994). Here are a few highlights.

Software Created for Instructional Use

Like most observers of computers and education since Levien et.al. (1971) our group's attention had initially focused on software created for undergraduate instruction, especially distributable curricular courseware for directed instruction. However, our group of academics, publishers, and others quickly realized that we had heard of only a few pieces of such courseware that were both valuable and viable. (There was a very different type of software which provided many examples of value and viability; more on that software in the next section of this essay.)

Finding so few examples of valuable, viable course for directed instruction was not a huge surprise. We knew that the market for computer courseware had proved to be small and brittle, for several reasons.

First, higher education is smaller than the kindergarten-high school market, and the variety of ways in which one course may be taught is greater. So this is not a big market to begin with.

Second, some faculty members don't like to use technology. Eliminate them from the market.

Third, some faculty members don't have the proper hardware and software platform. Eliminate them from the market, too.
Fourth, some faculty members like technology and have the right platform but don't like the teaching approach embodied in the courseware.

Fifth, some faculty members are perfect candidates but can't afford the software at the offered price, or their students can't because they are already paying big dollars for their textbooks.

Sixth, some faculty members fail to discover that the package exists.

Seventh, some faculty (and their student) copy software illegally, further shrinking the market to minuscule proportions.

A tiny market was one key challenge to viability of prepackaged courseware. A second, equally formidable problem was the difficulty of financing the creation of upgrades (new versions) and ports (translations of the software to allow it to operate with upgraded or new operating systems).

Courseware lives the short life of a mayfly. When the underlying hardware and operating systems change, courseware that is not ported no longer runs on available machines. Software that no longer has the look and feel of current software in business also faces a shrinking market because it looks outmoded.

In contrast, curricular change moves with the speed of a glacier: on a national scale it may take five, ten or more years for a course to change. Thus, if courseware is not ported and upgraded regularly, it is unlikely to live long enough to become viable, let alone to foster curricular change.

Unfortunately, we discovered that the cost of porting and upgrading was usually a significant fraction of what it cost to develop the software in the first place, despite annual expectations that new languages and new authoring systems would reduce those costs. An iron law usually kills costly courseware:

1. If it costs a lot to develop a piece of courseware, upgrades were also expensive.  
2. Yet the income yielded by version 1 was usually insufficient to pay for an expensive upgrade; too few people were willing to buy it, especially when it was still new, untried, and perhaps implicitly requiring a major rethinking of the course in order to exploit the software. So patience was required. Unhappily faculty developers and grant-givers rarely had much incentive to sacrifice in order to create a port or an upgrade. The big incentives came from developing something new, not in keeping something old (and not yet successful) alive a while longer.
3. Thus large, expensive pieces of courseware rarely are upgraded or ported. [One publisher observed wryly that the more money a foundation put into developing a piece of courseware, the less likely it was to ever be a success!]

There are at least three reasons for the high costs of upgrades and ports: 1) continually rising standards for what courseware should do and look like, 2) the difficulty of designing and debugging a branching, interactive program, and 3) the lack of standards for cross-platform development. (This third factor is not quite as formidable as it once was, but the first two continue to pose just as great an expense as ever.)

The Valuable Viable Software (VVS) Project studied only computer software. It should be noted that video is a more viable medium for at least two reasons.

First, standards for its hardware have been relatively static, so there is no technological reason not to continue using a curricular video tape for years.

Second, video courseware can be used to offer programs for learners who find it difficult or impossible to attend courses on campus, thus increasing enrollment while speeding the time needed to graduate. In the United States, a few colleges producing video courseware have even been able to invest hundreds of thousands of dollars in a course and then recoup the investment through selling the materials to others while gaining income through their own increased enrollment.

The VVS Project did document three families of curricular courseware that might be of interest. Because we were doing case studies on the basis of examples known to our team, it is not possible to make any statements about the relative frequency of each family.

- "Niche curricular software" - this family of software was often ported and upgraded because it was so inexpensive to develop in the first place (roughly $5000 to $30,000). It was usually quite limited in its
scope and role in the curriculum (hence the term "niche"). A combination of income and developer "passion" was sufficient to support needed upgrades and ports. This software was usually disarmingly crude (in part because it was indeed old -- that was a qualification to be studied in the first place -- software needed to have survived). Because its scope was limited, it was usually seen by faculty and students as a labor saving device. Its limited scope also meant that it was not revolutionary.

- "Course-sized bodies of materials." We found several cases of computer software that supported a semester's worth of work, usually with a combination of didactic material and simulations or tutorials. Designed for very popular courses and supporting a significant amount of work, they (just barely) managed viability, despite formidable obstacles. We believe that there are very few such viable packages, for reasons discussed earlier in this essay.

- "Extensible Software." This family of software owes part of its viability to features that can be tailored by users and extended by adding new components, part to an architecture that is exceptionally easy to port and upgrade (often an archive format), and part to the ability to solicit and integrate contributions from users. The "Slice of Life" videodisc grows by attracting new slides from users, for example, and in 1992 was in its sixth edition.

Worldware and Student Editions

When the VVS Project team first convened and began to share examples of valuable viable software, we soon realized that the vast majority of the successes were pieces of software originally designed for uses other than undergraduate instruction. Because their origins and chief market were in the larger world (outside pure instruction), we called them "worldware." Worldware includes productivity tools and software used in work, e.g., molecular modeling tools, computer aided design, software used by professional musicians, software used to manage and search research collections, the databases themselves, communications packages, the Internet…the list is long and its penetration into undergraduate instruction deep. The VVS book includes several case studies of worldware.

The VVS team later defined a second category of valuable viable software -- the "student edition" -- to be software that is like a piece of worldware but that is marketed explicitly for instructional purposes and that, in some cases, has also been tailored for instruction. There can be a rich interaction between student editions and worldware. Minitab is statistical software that was originally developed by faculty members as a student tool. Its ease of use and power soon made it popular as professional software. Some of the faculty members and graduate students who developed it then started a company to market and improve the product: Minitab, Inc. Today, closing the circle, there is a student edition of Minitab, developed and marketed by Addison-Wesley.

The Viability of Worldware and Student Editions

Worldware and student editions (both used for learning by doing) are usually more viable than distributable courseware (used for directed instruction).

1. Worldware and student editions are often long-lived and available in versions for multiple platforms (DOS/Windows, Macintosh, and sometimes UNIX). Because of the potential to make money from multiple markets, several developers may race one another to produce more powerful, less expensive versions. To be competitive, new versions will often run files from older versions, and even from competitor's packages. Thus faculty members can be confident that, if they invest time in rethinking portions of a course to take advantage of worldware, they can use the new course materials for as long as they choose.

2. Because worldware is rarely specific to a particular course and approach to instruction, the same worldware can be used for different purposes by faculty members with entirely different instructional approaches and for many different courses as well.

3. Students come in already wanting to learn about and use worldware. They know that people in the real world are using worldware to think in new ways about their problems, and even to tackle new problems. Students know that employers and graduate programs expect college graduates to already have learned the rudiments of those new ways of thinking.

4. Faculty members are likely to be familiar with the worldware already and perhaps use it in their own research or consulting.

5. Because worldware is already used in a wide market, marketing and technical support are likely to be superior to that for courseware.
The Value and Limits of Worldware and Student Editions

Because most people assume technology is supposed to revolutionize directed instruction, worldware for learning by doing is treated as irrelevant. However worldware is playing a role in transforming courses and extending them to new learners. For example, statistics software has transformed the objectives and teaching methods of many statistics courses. On-line research libraries and databases have enriched academic programs for students on- and off-campus. E-mail programs, the Internet and Webchat support the development of academic communities whose members are not restricted to those who live within campus walls.

Summary

Faculty crafted for instructional purposes can be of enormous value. Such software projects have attracted the love and sacrifice of developers, funders and initial users. But too often such projects have been killed before their investments could be justified by educational returns, not because they lacked value but because of economic factors that prevented necessary upgrades. Meanwhile, almost invisibly, worldware and student editions, also educationally valuable but facing a more favorable economic climate, have been increasing in use.

References


Learning Styles and Hypermedia Courseware Usage: Is There a Connection?

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Abstract
This paper discusses the results of a pilot study to determine if learning style and use of hypermedia courseware are related, with a view to influencing hypermedia courseware design. The students involved in the study were completing the first year, first semester programming subject of a Bachelor of Computing (Application Development) degree. Their learning style and learning stages were recorded using Kolb's Learning Style Inventory [Kolb, 85]. They were then exposed to the Computer Based Training (CBT) package, which recorded, via a monitor, their usage and progression through the package. The results show that the learning stage Reflective Observation correlated highly with the instructional part of the CBT package, and that Concrete Experience correlated with one of the examples of the package. Abstract Conceptualisation correlated negatively with the time spent on the instructional part, but this may have been due to the small sample size.

Introduction
Computer-based hypermedia courseware has the potential to provide a customised learning environment that allows a student to use the materials to suit his/her preferred or primary learning style. However, environments that allow the learner total control over the learning environment may not serve the student's best interests. [Jonassen & Grabinger 90] state that
"research has shown consistently that learners, when given control over instructional variables, do not make the best decisions. Those who need the most instructional support (underachievers) frequently select the least, and those who need the least (overachievers) frequently select the most. Learners in learner control treatments have regularly learned less than those in treatments controlled by the instructor or by an adaptive instructional design" (p.16).

If a student's mastery of a task is influenced by their primary learning stage [see Cornwall & Manfredo 94], and if there is a relationship between a student's use of hypermedia courseware and his/her preferred learning style, then it would be valuable to instructional designers of hypermedia courseware to exploit this to assist students to make the best use of that package. [Whalley 90] indicates that while browsing is the most natural mode of study with hypertext, it is not what many educators would consider the most efficacious method to achieve the learning they wish to encourage. Some guidance in choice of learning path should be considered, while not impeding the student's development of higher level learning skills. This study implements a methodology for the evaluation of hypermedia courseware proposed by [Ellis & Dospisil 94]. The first stage of this methodology is to determine if a relationship exists between a student's preferred learning style or primary learning stage, and his /her use of a computer based training package using hypermedia principles.

Students Involved in the Study
Twenty-four students were involved in the pilot study, of which eighteen completed the Learning Style Inventory and also used the CBT package. All students were enrolled in the Programming 1 subject as part of the Bachelor of Computing (Application Development) degree at Monash University's Peninsula School of Computing and Information Technology. All students had prior exposure to programming, either as part of a computing diploma in Malaysia or through a previous attempt at the Programming 1 subject.
Kolb's Learning Style Inventory (LSI)

The Kolb Learning Style Inventory [Kolb 85] refers to four stages of the learning cycle as follows:

- **Concrete Experience (CE)** - learning from specific experiences, emphasising personal involvement and a reliance on feelings rather than a systematic approach to problem solving.
- **Reflective Observation (RO)** - learning using objectivity and careful judgement to form opinions, but without necessarily taking action.
- **Abstract Conceptualisation (AC)** - learning from the logical analysis of ideas, relying on systematic planning and theory development.
- **Active Experimentation (AE)** - learning by experimenting to influence situations to achieve learning.

While people cycle through all stages of learning, most have a predominant or preferred stage for achieving satisfactory learning, causing a preferred learning style to develop. Kolb's learning styles [Kolb 84] are:

- **Accommodator** - (AE - CE) - learns primarily from hands-on experience.
- **Converger** - (AE - AC) - learns best by finding practical uses for ideas and theories.
- **Assimilator** - (RO - AC) - learns primarily by using abstract ideas and concepts.
- **Diverger** - (RO - CE) - learns primarily by viewing different situations from many different points of view.

While there has been some questioning of the validity of Kolb's LSI [Cornwall et al. 91; Geiger et al. 92], mainly regarding the ipsative form of the test, most researchers agree there is support for people exhibiting one of the four stages of the learning cycle as a dominant trait [Manfredo 89; Geiger et al. 93; Romero et al. 92]. [Kolb 85] indicates that converger skills are necessary for those in specialist and technology careers, and assimilator skills are required for effectiveness in information and science careers. [Sein & Robey 91], using Kolb's LSI, found that students with a converger learning style had the highest overall performance for training of novices in the use of a computer electronic mail system and that "performance can be enhanced by tailoring instructional methods to accommodate individual differences in learning style" (p. 246). [Hudak & Anderson 90] found that a low score on the concrete experience stage of Kolb's LSI correlated with success in introductory Computer Science and Statistics courses ($r = -0.68$). [Esichaikul et al. 94] found the preferred learning style for high success in problem solving, to be the converger, with abstract conceptualisers producing a higher quality result than those who prefer concrete experience.

The Computer Based Training Package

**Instructional Content of the Package**

The computer based training package developed for the pilot study was written using the authoring software Asymetrix Multimedia Toolbook 3.0 and covered the basic concept of array structures within the C programming language. This particular area was selected because it lends itself to visual and animation techniques that other conceptual areas of programming covered in the first course do not. The CBT package was designed to support the lecture and tutorial material, not to provide stand-alone instruction.

**Design of the Package**

The package was split into three sections.

- An instructional section covering the basic concepts of arrays - what is an array, defining arrays, initialising arrays, accessing array elements using subscripts and rules for subscripts. This was provided to support the learning stages of RO and AC. Animations and hotword accesses were provided to support the learning stage of AE.
- An "examples" section that showed the use of arrays in C programs. The student could step through each line of the program code and be given an explanation of each statement in the program. This was provided to support the learning stages of CE and AE.
A "show and try" section with questions for the student to answer. The student could have the solution "shown" to them with explanations (to support the RO learning stage), or could "try" to answer the question themselves (to support AE to a limited extent).

As [Geiger et al. 93] state, "One thesis of the Experiential Learning Model [as described by Kolb] is that individuals need to choose between the various learning abilities in different learning situations and also as an overall strategy in the way new knowledge is acquired" (p. 718).

The inclusion of the three sections of the CBT attempts to support this idea by providing material that supports all four learning stages. Various multimedia and hypermedia techniques were employed to increase the interactivity of the package, and provide appropriate linkages to support the learning environment.

- Textual Information - The instructional section provided a textual explanation of each concept covered. The examples section provided an explanation of each line of code.
- Hotwords - These were used to provide appropriate definitions and explanations of terms used in the text and C code, allowing the student to determine their need to facilitate their learning.
- Navigation Controls - Two types of navigation controls were employed, providing the learner with full control over the order of presentation of the CBT material. The sequential controls allowed the student to move sequentially (both forwards and backwards) through each of the three sections of the CBT. They also provided a means of progressing logically through the conceptual material in the instructional section, and a step-through mechanism for the code in the examples section.

Hyperlinks were provided in two ways. First, as a map that could be accessed from any page in the CBT. The map highlighted in red the page the map access was triggered from, and indicated areas already visited by a tick in a check box. [see Fig. 1]. By clicking on a topic, the student would proceed directly to the page selected. Second, in the "examples" and "show and try" portions of the CBT, relevant instructional topics were provided as hyperlinks that allowed the student to call up that page of information. A "back" button returned the student to the original screen.

- Animations - These were employed in the instructional portion of the CBT, providing visual input and an active display of information.

The Monitoring System

A monitor, attached to the CBT to record a student's progress through the package, was written as a dynamic link library (DLL) function in the programming language C, and accessed by the CBT package through calls to the DLL function embedded in theToolbook script. The monitor recorded the following information:

- student's name and identity number, recorded once upon entry to the CBT package.
- the time of entry and the page name for each page entered, providing a timed trace of the student's progression through the CBT package, allowing analysis of, not only the order in which the CBT was used, but also the amount of time spent at each stage.
- the name, type and time of access of an object. These were recorded for buttons, animation icons, hotwords and text entry fields, providing a timed trace of the use of objects. Hotwords had both entry and exit recorded. When a student keyed in an answer for an exercise, the monitor recorded the activation of the try icon and a record of the accuracy of the response (e. correct or incorrect).

Method

At the start of the semester, students completed the revised version of Kolb's Learning Style Inventory [Kolb 85]. The students were presented with the CBT package during a two-hour tutorial session in week eight of the semester. The same topic had been covered as part of the previous week's lecture. Students were shown how to start the package and a brief explanation of the three main parts of the package was given. They were informed that they could attempt the three parts in any order they chose. No time limit was set for them to use the package. After all students had finished using the package, they were informed that a trace file recording their use of the package had been created. At this point, they could withdraw from the research project if they wished. The trace files were collected by the researcher and deleted from the machine in the tutorial laboratory.
For each student, the access time and number of accesses were recorded for the total application, each of the three main sections, each topic in the instruction section, each example and each exercise. The number of accesses of the hotwords and animations were also recorded.

In calculating the time for each part, accesses to a session of one second or less were not included as this was considered to be an access for navigation purposes rather than information. These were, however, included in the count of the number of accesses, as the method of navigation was considered relevant.

A series of correlations were made for each of the above values with each of the learning stages (both value and percentage as determined by [Kolb 85], as well as with the values on the two axes (AE - RO and AC - CE) that determine the student's learning style.

![Figure 1: The Map Page of the CBT Package](image)

**Table 1: Student's Learning Style and Primary Learning Stage**

<table>
<thead>
<tr>
<th>Student</th>
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<th>Primary Learning Stage</th>
<th>Student</th>
<th>Learning Style</th>
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<td>10</td>
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<td>2</td>
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<td>5</td>
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<td>6</td>
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<td>Converger</td>
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<td>8</td>
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<td>17</td>
<td>Accommodator</td>
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<td>9</td>
<td>Assimilator</td>
<td>Abstract Conceptualisation</td>
<td>18</td>
<td>Accommodator</td>
<td>Active Experimentation</td>
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Table 1 [see Tab. 1] shows the breakdown of the student's learning style and their primary learning stage. This follows similar patterns found by [Ellis & Dospisil 94] previously, with a larger proportion of students being Assimilators and having a primary learning stage of Abstract Conceptualisation.

Instructional Part

For the instructional part of the CBT package no significant results were found for CE or AE with either the time taken or number of accesses. RO (both value and percentage), however, correlated significantly ($p < 0.001$) with the time taken to access the 'Defining Arrays' screen ($r = 0.79$ - value; $r = 0.73$ - percentage), and also with the total access time for the instructional part ($p < 0.01$, $r = 0.67$ - value; $r = 0.64$ - percentage). With the exception of the rules part, RO also correlated highly with all counts of the number of accesses in the instructional part of the CBT package ($r = 0.65$ to $0.73$ - value, $r = 0.55$ to $0.68$ - percentage). AC showed no significant results with the number of accesses, but did produce significant results ($p < 0.01$) with the total time taken on this part of the package ($r = 0.63$ - both value and percentage) as well as the time to use the initialising arrays part ($r = 0.64$ - value; $r = 0.63$ - percentage). For the two values that determine the student's learning style, AC-CE produced no significant correlations for either time or number of accesses for the instructional part, however AE-RO showed a negative correlation ($p < 0.001$, $r = -0.72$) with the time for the definition part of the instructions, and negative correlations ($p < 0.01$) with the number of accesses of the 'What-is?' ($r = -0.57$), 'Definition' ($r = -0.57$) and 'Initialising' ($r = -0.63$) parts of the instructions.

For the animations in the instructional part, the only significant correlation ($p < 0.01$) was that of AE (both value and percentage) with the number of animations accessed in the 'Definition of an Array' part ($r = -0.60$ - value; $r = -0.62$ - percentage). The number of hotword accesses were so few that it was deemed impractical to analyse this result statistically.

Examples and Exercises Parts

CE showed a significant negative correlation with both number of accesses ($p < 0.01$, $r = -0.55$ - value, $r = -0.59$ - percentage) and the time taken ($p < 0.01$, $r = -0.56$ - value and percentage) to access Example 2. For the exercises, the only significant results ($p < 0.01$) occurred between the number of accesses to the 'Show' portion of the 'Initialising an Array' exercise and that of AE ($r = -0.5701$ - value) and CE ($r = 0.5451$ - value).

Discussion

The results for the instructional part support the notion that those with a primary learning stage of RO, who place a reliance on objectivity and careful judgement, would spend more time and access the information more frequently. Given the significant results for RO, the negative correlations for AE-RO with the instructional parts are not surprising, as the lower the value of this ability, the greater the tendency to use the RO learning stage rather than the AE learning stage. One could perhaps also expect those with a primary learning stage of AC to spend more time on the instructional part, however this proved not to be the case. In fact, AC showed a negative correlation with the time taken. This may be due to the limited sample size and a larger sample may show different results. While a correlation was found between AE and the animations access, this was unexpectedly negative as one would suppose that those with a preferred stage of active experimentation would use the animations more, not less. Examination of the scatterplot of these variables indicated that the relationship was non-linear. Further investigation with a larger sample is needed to validate this result.

While some significant results occurred for the examples portion of the CBT with CE, most students accessed the examples only once or twice, so these results are likely to be unreliable. For the exercises, the negative correlation of AE and being shown a solution, would be what one would expect, but no corresponding positive correlation occurred with trying the answer. This may be due to a student trying the answer once only if he/she gets the correct answer. The correlation of CE and being shown a solution is also not surprising, as one could expect a person who learns from specific experiences to prefer being shown a solution.
Conclusions

While the results of this pilot study should be treated with caution because of the small sample and the use of one CBT package, it has been shown that those with reflective observation as their primary learning stage require more accesses of, and a greater amount of time to access, the information. Direction through instructional paths would seem appropriate for these people, while direction through examples would be more appropriate for those with CE as their primary learning stage.

Further Research

The second stage of this pilot study is to investigate possible relationships between the student's success in the programming subject (as measured by their end of semester results), learning style, primary learning stage and use of the CBT package. A repetition of the study using a larger sample and more than one CBT package is needed to determine the validity of the pilot study. It is intended to develop three more CBT modules for the same course and monitor their use with the first semester 1996 group of approximately 120 students.

References


Acknowledgments

This pilot would not have been possible without the work of two honours students; Tom Leyden who implemented the CBT package using Toolbook, and Adam Scott who developed and implemented the monitoring device. Their assistance is greatly appreciated by the author.
Networking in Fifth Grade: Learning Through Exchanging Questions and Answers

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Abstract: This work demonstrates what nine- and ten-year-old children can learn through online interaction with their peers. A computer newsgroup environment was provided to students in one elementary school. Students were encouraged to use it to exchange messages about programming questions, as well as other topics. The case study of one fifth-grade girl provides a description of patterns of interaction and how the children’s questions and answers developed over time.

Introduction

One week into her design of an educational video game, ten-year-old Renee asked the following question:

How do you make words appear on the screen when you reach a certain point of the screen or you reach a shape that is on the screen?

This query itself might be unsurprising, but the fact that this quiet girl addressed it to the combined populations of two classrooms, rather than to a teacher or one of her friends, is unusual. In the environment described in this paper, however, it was welcome and became a frequent occurrence. Seven fifth-graders answered this question, three from Renee’s class and four from the other. Of these children, four were male and three were female; three were African-American, one was Hispanic, and three were Caucasian. Given that these two classes rarely had contact about academic matters, and that even among themselves, these boys and girls most often asked questions of friends of their own gender, these responses were somewhat surprising. After receiving eight helpful messages, Renee replied to her own question, saying:

Stop answering this question. #1, I have too many answers, and #2, I have solved my problem and am using something else. Thank-you very much.

Two children replied to this message with additional information.

Children can learn through both asking and answering authentic questions—questions which are personally important to them. When asking a question, a child needs to articulate what he or she wants to learn or obtain. If the response is not what was desired, the child has the opportunity to observe a different perspective on the question. The child may also realize that a single statement of a question may provoke different reactions in different people. Similarly, answering a question requires articulation of thoughts; in addition, it implies some interpretation of the question and what kind of answer was desired. Although these might not be conscious processes or ones in which people choose to engage, they are possible in a question/answer scenario, particularly when the participants really want to communicate.

To study these issues as well as questions of what children can learn online, I decided to provide a computer-based environment and activities in which children can communicate easily and feedback is valued. The software I helped design and then used is called NewsMaker; it is a computer-based newsgroup environment similar to Usenet written by Mark Kortekaas [1994]. I introduced NewsMaker to three classrooms of fifth-grade and two of fourth-graders.

The students were given the ability to use NewsMaker to read, write, and modify articles, but were not assigned to use it for any particular purpose. Although children posted many kinds of messages to newsgroups they created, most didn’t use the system to hold conversations. The ones who did were those discussing particular projects.
Students in one advanced-work fifth-grade class were beginning a project to design and create educational video games to teach younger students about the ocean [Kafai 1995]. I showed them how they could use NewsMaker to ask questions about their project, and told the other advanced-work fifth-grade students that they could the system to be online consultants for the new designers, since they had already done similar projects.

These children interacted online several times a week during the last four months of the school year. Their experiences show what can happen when children are given the ability to talk freely online about things which are important to them. I have chosen the case study of one girl in particular to demonstrate patterns of interaction and how they changed over time.

Renee’s First Questions

Renee was one of the game designers. A quiet, petite girl, she enjoyed both working on the computers and giggling with her friends—when she was alone with them. She wanted to create a game in which the player would control a fish, guiding it to the pots of gold that would reveal facts about the ocean. Any time the fish crossed one of the barriers she created, the player would be asked a question about the ocean. In addition, she wanted to have a whale which could chase the fish. It would be made out of two shapes (to make it larger than the fish), and controlled either by the computer or by another person, depending on programmatic constraints. Of course, Renee didn’t have the entire design set out on the first day; she, like most of the children, had plans which she modified over time.

On the first day of the game design project, a girl named Whitney had a question for everyone, so I showed her how to use NewsMaker to post it. When Renee had a question the next day, Whitney showed her how to use the system. Renee wrote:

How do you make two shapes move like one?

She did not sign this message, but since all messages had their author’s name in the header, it was obvious who had written it. That day she received two replies from consultants (the fifth-graders who had previously done a game design project). Suzanne’s response read simply:

RENAE I DO NOT KNOW

I was surprised to read a message that said only “I don’t know;” after all, questions which are broadcast to a group are not generally directed to particular people, so it does not matter if one reader does not know the answer. This was only one of several such messages, many of which also included a possible alternative solution. In interviews I conducted prior to this project, several children had told me that they were uncomfortable when one of their friends asked them something that they did not know; it seemed as if they would “look stupid” if they admitted ignorance. In this online setting, however, it seemed to be a way for children to indicate that they wanted to help, but were unable to.

Ken, a rather loud, quick consultant, also answered Renee’s question. This was another surprise, since it meant a boy was answering a girl’s question. I had observed Ken’s class during their computer time, and noticed that boys would only talk to boys and girls would only talk to girls; I never saw a boy asking a girl a question or vice versa. Ken gave a matter-of-fact response which seemed to answer Renee’s question. Apparently it did not provide the information Renee wanted, however, because on the next day of the project, she posted this:

How do you make one shape fallow another? One shape moving by the arrow or letter keys, the other moving by computer, following the other shape?

Renee

Albert’s reply was yet another type of answer: a message which informed the questioner that someone else might have the answer.

Talk to Jorge. You two are in the same boat. (Pardon the pun)

Albert, a small and quiet boy, was the acknowledged computer expert in the classroom; he became very active online. Although he could probably have answered this question directly, as he did with many others, in this case he chose to redirect the questioner. This was probably more efficient; after all, Jorge had (with help) just solved a similar problem.

Lisa also answered the question; since she was a good friend of Renee’s, her sharp reply was somewhat surprising:
Renee, for the first thing you spelled follow wrong, for the second thing you do it by attaching the shapes. simple. ask me for details at lunch.

This was the first “spelling flame” I noticed, although later in the project there were a few more. I believe that there were at least two reasons for Lisa’s abrupt manner: she was generally rather tactless and her friendship with Renee was a comfortable one in which criticism could be taken as an attempt to help. Lisa’s online communication was not particularly clear, however her teacher said that she often didn’t take the time to write clearly in other settings either.

Other students gave Renee more details in posts they wrote during the next session. Unfortunately, they did not seem to address the question to Renee’s satisfaction. Tina was a new student in the consultants’ classroom; a tall girl who loved to dance and to laugh, she seemed to want to help even though she didn’t have much experience. She wrote:

WELL YOU COULD USE YOUR FOUR TURTLES, THEN SEE WHAT HAPPENS.
TINA H.-307

When I read this, and other messages like it, I was surprised; if these children had been asked “How do I build a treehouse?” would they have said “Use some boards and see what happens?” Renee did not seem to take offense, but replied by restating her question more clearly. Her reply demonstrated one type of reasoning which I considered important during this project: instead of assuming that the respondent was stupid, or just “not getting it,” several students would realize that what they themselves had written was unclear.

In real life it is very common for children of this age to assume that they are not at fault if someone doesn’t understand their words. There is no need for them to clarify what they said; after all, they already said it once, so the other guy must just be stupid. In their minds they have explained themselves completely; because they cannot review their verbal communication, all they have to go on is what they think they said.

In this online environment, however, children could go back and see what they had actually said. This happened many times during the project, and several children were surprised to see what they had really typed. I heard children say “oh, my question wasn’t clear!” to others or just to themselves; another comment they made was “I should’ve explained that I’d already tried that!”

Renee’s Answers to Others

While Renee asked several questions, she replied to quite a few as well. Many of her answers sounded as if they were written by a stereotypically uncertain young girl. During the session in which Renee posted her second and third questions, Albert wrote:

Does anyone know how to reverse a shape: make the black part white, and the white part black?

Lisa replied simply “no,” but Renee realized that there was an ambiguity in the question. Instead of assuming she knew which question Albert meant, Renee responded by asking for clarification. After Albert replied, she suggested a solution:

Can't you just click space on all of the blocks in the square and then make the picture by clicking again?
Then the black or background would be white and the picture or the white would be black?

This uncertainty was found more often in posts by girls than in those by boys. It could be that Renee used it in this case because she was giving advice to the class’ “computer expert”, but she also seemed hesitant when answering a question by one of the other girls who was not considered an authority:

Maybe you could color the box black as if you were writing words. I'm not sure if it will work, but it might,

I do not mean to suggest that all of Renee’s replies were uncertain or apologetic, but several of them were. The important point is that not only did Renee ask questions publicly, she also spent time answering her classmates’ questions in a constructive and supportive manner.

Beyond Technical Topics

Although most questions the children asked online concerned strictly technical issues, not all of them did. For example, some students discussed the topics of their games and others talked about ways to make their games educational. Several weeks into her project, Lisa addressed a question about the style of her game to Renee. Renee’s response was quite authoritative, even after Albert had replied:
RENEE, WHAT DO YOU DO ON YOUR GAME WHEN SOMEONE GETS AN ANSWER WRONG?
> How about printing on the screen, “Wrong!”
> Albert
I agree with Albert, say "wrong." But you should also explain the correct answer, and sometimes put "wrong" in a funnier way. For example, put nope, uh-uh, think again, etc. Make it fun to be wrong!

Renee

Very few messages were directed to a certain person as this one was, and, as in this case, other students seemed to ignore the direction and answer anyway. Rather than contradicting Albert’s suggestion or ignoring him as an annoying interloper, however, Renee responded in a way that incorporated his comments. It is also interesting to note that Lisa asked Renee a question online, rather than doing so in person, even though they are friends in the same classroom.

Another non-technical topic which generated discussion was raised by a thoughtful girl named Tisha. She wrote:

**Do you think that by asking trick questions you are teaching someone else?**

**Tell me what you think**

Tisha

I was very glad to see the children asking for opinions on non-technical aspects of their programs; most traditional school settings don’t seem to welcome children’s discussions of their personal pedagogical viewpoints. Renee answered Tisha during the next session:

I think that it depends on the trick question. Can you give an example? I think it might just confuse people with the correct answer, but give an example.

Kim, a consultant, wrote that she thought including trick questions “wouldn’t be right” because the person playing the game would not learn the real answer. Renee then responded again, saying that she felt trick questions could add fun to Tisha’s game, as long as Tisha was careful to explain the right answer and not confuse anyone.

These girls along with the other three who responded were clearly focusing on the educational aspects of their games and paying attention to how the younger children would feel and what they would learn while playing the games. In addition to the online exchange, Tisha and Renee had a conversation about trick questions in person after posting these messages; Tisha told me that she wanted to talk to Renee about it (even though they weren’t friends) because Renee had asked her for examples.

Final Questions

The style of Renee’s messages changed over time. The ideas in her later messages were more clearly expressed than those in the early ones, and she gave more context for her questions. For example, in her final question, Renee explained what she did and did not want to happen:

At the end of my game, above my waves the words "You’ve been caught!!" appear. I want them to flash off and on 3 times the have them disappear completely. But I don't want my waves and everything underneath my waves to disappear.

#1. How can I make my words flash without my main screen flashing also, just the words.
#2. How do I make my words disappear completely without my main screen also disappearing. I already tried rg, ct, ht. Will not having "pd" at the end of my 'setpos' help??? HELP!

Children who answered this question took advantage of its clarity and organization.

Renee’s game progressed much as her messages did. She was able to work out her problems and produce a complete game which other children admired. She succeeded in creating a whale for a second player to control to chase the first player’s fish. If the whale was able to catch the fish, the game ended, even if all the pots of gold had not been retrieved.

Lessons

One of my original questions was whether I would be able to provide a space that would not exclude any children due to their gender, ethnic group, clique, or ability level. I also wanted to have a space where the
children would be free to express themselves on important topics which are not typically supported in schools. I believe that for these children, I was able to reach these goals.

Given only the messages quoted above, it would seem that the girls in this project wrote much more than boys did. Although Renee did write a high number of messages compared to average for her class (she wrote 23 and the average was 12), she was not the most prolific writer in her class. For example, Albert wrote 41 messages, Emilie 31, Stephan 23, Carrie 22, and Lisa 20. Of the 235 messages written by the twenty game designers, 138 of them were by girls. There were ten girls and eight boys in the consultants’ class; 86 messages were from girls and 66 from boys. These few statistics show that girls participated in this online environment at least as much as the boys did, and in many cases, more than the boys.

The context of the children’s communication was critical to the success of the project. The fact that the game designers were each creating something that was personally important and which they would be able to share with others in the school meant that each one had a personal interest in seeing their communication succeed [Papert 1993, 1991, 1980]. It was also important that the children had on-going contact with each other; although consulting can be done on a more infrequent basis [Kafai & Harel 1991], in this project, the children whose messages developed the most were those who spent more than one or two sessions online.

The public nature of all messages may well have caused many children to think twice before writing anything offensive. Although some boys initially wrote rude messages, ending their answers with “Duh!!!”, the response they received from their peers quickly put an end to the behavior [Evard 1996b]. Teachers were not major participants in the project, but it was clear that they could read any of the messages. In addition, the messages were not anonymous, so there could have been negative consequences for unacceptable behavior.

This network was local to the school, and all of the children on it could locate anyone who had written a message. Because the author’s real name appeared with every message, everyone else knew or could learn who each author was and could find him or her in person. This could be very positive, as in the case where Tisha and Renee talked in person after exchanging messages online, but it could also mean that if a message was offensive, other children could talk to the author in person about it.

Another aspect of the network being in a common physical community was that children may have taken others’ real-life personalities into account when reading their messages. For example, Renee may have been offended by Lisa’s spelling flame message if she hadn’t known what Lisa was like in person. Children in this environment knew that there was a real person behind each message and that there were real repercussions of the messages.

The students’ usage of NewsMaker changed over time in at least two dimensions: the types of topics discussed, and the characteristics of the messages. Three main types of issues were discussed electronically by the designers and consultants during the first three weeks of their projects: programming issues, issues of the content of their games, and social etiquette [Evard 1996a]. Later in the project the students also discussed educational issues, and questions such as those about how things should look disappeared. There were fewer questions later in the project than there were in the first few days, but the questions which were posted were increasingly detailed and descriptive. More of the questions in the later weeks of the project requested opinions rather than simply how to do something. The quality of discussion, both of topics and of discourse, increased over time.

I believe that posting questions and answers in this public environment has helped the students’ own words become objects for them to think with and about. I am continuing to pursue these issues in further projects.

References


I would like to thank the children and their teachers for participating in this project and discussing their perspectives with me. Mark Kortekaas not only encouraged this use of his software, but allowed me to participate in its design and supported my work with it; his aid was invaluable to me. Yasmin Kafai was my mentor during my first two years at Project Headlight; without her support, this work would not have been possible. I would also like to thank Seymour Papert and Walter Bender for their support during this project and others. The preparation of this paper was supported by the MIT Media Laboratory’s News in the Future Consortium, as well as by the National Science Foundation (Grant # MDR 8751190), the LEGO Group, Nintendo Inc., Japan, IBM Corporation. The ideas expressed here do not necessarily reflect the positions of the supporting agencies.
Abstract: In this paper we present the results of the experimentation of a hypertext for teaching mathematics, Hypercalculus, specifically designed for teaching how to learn to solve calculus problems. The test involved a sample of students with difficulties in learning mathematics, which therefore were not able to solve calculus exercises. We then explain the modifications we introduced in the first prototype of Hypercalculus in consequence to the results of the experimentation. At present we are testing the second version of the prototype to evaluate its didactic value, and we are planning new improvements. Besides that, the attitude of the students during the experimentation led us to new reflections on the search for the best approach for teaching calculus.

1 Hypercalculus: the First Prototype

In a previous work [Farinetti & Scarafiotti, 1995a] we tried to highlight the characteristics (buttons, hot words) of a hypertext for teaching, in particular for teaching mathematics, and we presented Hypercalculus, a hypertext for teaching how to solve calculus problems.

Hypercalculus is part of a wider project, Hypermath [Giannetti, Montessoro & Scarafiotti, 1993a] [Scarafiotti & Giannetti, 1994] [Carrara et al., 1993] [Giannetti, Montessoro & Scarafiotti, 1993b], a hypermedia system for teaching calculus designed for students at the first year of the master degree in engineering or architecture at Politecnico di Torino.

The contents are relative to a calculus course for this category of students: limits, sequences, series, integrals, derivatives and so on. Each topic is examined under the point of view of epistemology (outline of mathematics history), of theory (theorems, demonstrations, properties) and of practice (examples, proposed exercises). Appendices are also available, with table of contents, algorithms, references and a glossary.

Hypercalculus is the sub-project which deals with the non trivial aspect of the practice, and its aim it to teach how to learn to solve calculus problems [Farinetti & Scarafiotti, 1995b] [Scarafiotti, Giannetti & Alloatti, 1994].

The first prototype contains thirty exercises, and most of them are demonstration of theorems applied on specified series, sequences or integrals. Two models of exercises are implemented in Hypercalculus: the guided model and non-guided model, and the user can reach both of them from the page which contains the statement of the problem.

In the guided model the solution is presented step by step to the students, and the tool stops after each step, so that the users can choose whether the help is enough for them, or if they need more hints; this is useful when the students are not able to solve the problem on their own, or when they don’t even want to try.

In the non-guided model the students are encouraged to look for a strategy and to find their own solution; this is implemented through a page in which the main steps of one or more strategies for the solution appear in
open order on the left side of the screen; all the steps are correct (we do not want to induce confusion or misconceptions), but only some of the are useful and applicable in the given context.

The task of the student is to choose the useful steps and reorganize them in the correct temporal and logical sequence, by dragging and dropping them into the right side of the screen. Once they have built what they consider to be the right solution process, they can check its correctness; if they failed, they have to start again from the beginning. In this version, we did not include hints for the solution at this level, since the students can look at the guided solution any time they want.

2 Evaluation: the Students Point of View

A few months ago we started an experimentation on Hypercalculus. Our students, which attend the first year of a master degree in engineering, used this tool as a means of self-evaluation and verification of their level of learning, after the conclusion of the calculus course.

Students had to fill a questionnaire after the use of the hypertext, whose aim was to give rise to the evaluation of the tool (see the appendix for the list of the questions). The questionnaire as certainly not enough to establish the communication between the students-users and the teacher-author, and interviews were made to gather the experiences of the students. We can briefly summarize the results in the following paragraphs.

Students did not experiment difficulties in the navigation of the hypertext, and the use of hot words and buttons resulted to be “friendly”.

As regards the guided, step-by-step solutions of the exercises, the passages between two consecutive steps are still not effective for the weaker students; they in fact look for exercises in which all the step, even the elementary ones, are highlighted. Clearly, even in the use of a computer-based learning tool, there are students which still wait for help coming from the “outside” instead of being involved in the discovery of a passage left hidden on purpose.

More interesting is the question that often the students put to the teacher-author: “Given a calculus problem, are the steps of the guided solution determined in a univocal way, or are more alternatives possible?”

As regards the non-guided solution, students had a good approach to them and found them very interesting, but while they easily succeeded in the first phase (the choice and the recovery of the statements which are applicable and useful in the context of the given exercise) they often experimented difficulties when they had to rearrange them in the correct temporal and logical sequence. Some students noticed also that the correct sequence is not always determined in an univocal way.

These difficulties often caused in the students the refusing to continue the research for the solution according to logical criteria: they tried all the sequences at random, and at last some of them even gave up.

This result is in accordance with the well known fact that one of the “weak” points of the hypertexts is the multiplication of the possibilities, which can cause distraction from the creative process.

3 The Second Version of Hypercalculus

3.1 What we Have Changed

Hypercalculus has been modified by the authors taking into account the results of the evaluation of the students, and trying to overcome the problems highlighted by them.

First of all we added new exercises, and the second version now contains fifty problems instead of thirty.

As regards the step-by-step solution of the exercises, a new button has been inserted in the page which contains the statement of the problem: the “strategy” one. This button leads to a page which is common to a set of exercises regarding the same disciplinary theme (for example sequences, series, integrals); in this page many possible alternatives for the solution of the typical problems of the particular disciplinary theme are listed, and the strategy that the teacher believes to be the most promising is highlighted. The guided solution of the exercise will, of course, follow this approach.
In this way the required analysis for solving mathematical problems is made explicit, and the hypertext can help the students which need just a hint to face a new problem. Moreover, learners are free to identify correct alternative strategies, and to follow their personal route to the solution comparing it with the teacher's one.

As regards the non-guided solution of the exercises, it has been modified in such a way that, when the student finds the correct position of one statement in the temporal and logical sequence, it remains fixed and cannot be moved from this position. In this way the students have some reference points, and they maintain more easily the determination of solving the problem, instead of trying the sequences at random.

3.1 What we are Going to Change

We are now planning further modifications, that will be implemented in Hypercalculus very soon.

Up until now, students are free of choosing either the guided solution of an exercise, or the non-guided one, in whichever order they prefer. We are now evaluating the possibility of creating a link of dependence between the two kinds of solutions proposed: a guided solution is always proposed first, in which a “macro” route is shown to the students; after they have examined it, they are invited to find a “micro” route, making explicit all the sub-steps through the non-guided solution.

According to us this approach will possibly prevent the feeling of discomfort experimented by many students.

We are also considering some improvements in the pages that contain the statements of the problems, in such a way to avoid problems of misconception or misunderstanding from the students, and to give them the first hint about the procedure of solution.

A “hot” area of each statement page will lead to a new formulation of the question with different words, as if the students ask: “Tell me more, and please change the form of the language in which the statement is written”.

Besides this and the “strategy” button, we will then include an “analogy” one; it leads to a page in which the statements of a number of analogous exercises are displayed. Analogies can belong to three different categories: analogies about the formulation (which help the students in understanding the meaning of the problem), about the subject (which encourage the identification of the context) or about the procedure (which help the choice of the strategy).

If the students are able to identify the analogy, they can recall from memory the experience of exercises they have already dealt with; otherwise the problem is new, and they have to find an original solution process: a second level of help is needed, the “strategy” button.

4 Evaluation: the Teacher's Point of View

The evaluation of the first version of Hypercalculus, besides giving directions to the authors on how to improve the tool and how to solve the problems highlighted by the students, resulted in an other important outcome: it helped the teacher to know more about the students.

Thanks to the observation of the interaction between learners and hypertext the teacher, which have a large number of students (about 250), could understand more easily the misconceptions which can stop the students and prevent them from finding the correct solution of the problems.

We think that the students need to acquired two distinct capabilities to solve calculus problems:
- they should be able to “decompose” a text-book of calculus in such a way they acquire concepts already connected in a network of meaning. This structure facilitates both the process of extension of the network when a new concept is introduced, and the application of knowledge when required;
- they should be able to apply different strategies and approaches for solving problems and answering to questions. In this second phase, the verification of the success of the first one is involved: the incapacity of solving a problem is often due to link errors, or to the absence of “dynamic links” in the network of meanings.

We would like to point out that the graph that simulates the decomposition of a mathematical subject is, in general, incomplete. This leads to the difficulty of applying the discipline when the student is not able to
complete it according to the requirements of the problem; the term “dynamic link” is used to express this situation.

If the students have not acquired these abilities, they have to start again the study using a different method, and their difficulties should encourage the teacher in experimenting new didactic strategies. The teachers therefore can evaluate the effectiveness of their lessons through the experience of the students.

With Hypercalculus, the teacher’s aim was to transmit the ability in solving calculus problem, and in general in reasoning about calculus. The comparison between the examination results of the students which used the tool, and the one that did not (even if applied on a small number of subjects) showed that the users became more active and personally involved in the solution of the problems. They learned to try, verify the solution, try again and not to give up at the first difficulty, and they became more critical and open to new strategies.

5 Conclusions and Future Work

The results of the first version of Hypercalculus were encouraging, and now we are testing the second one. The questionnaire used proved to be not completely adequate for the purpose, and we are planning an evaluation form which will distinguish between categories of students according to their level of promptness in learning. We wonder if the “good” students consider the hypertext as a useful tool and use it in a constructive way, or if they esteem it just as a curious and funny object: we would like to know if the “average” students feel assured and encouraged in achieving the goal, and if the “weak” ones gain the awareness of their critical situation, and look for help from the outside (teacher, books, and so on).

The students will also be encouraged in writing an “emotional” description of their experience with the hypertext.

Since we believe that the process of thinking is based to a great extent on the process of creating links and associations, we still consider hypertexts as useful tools for learning both new concepts and new strategies (from the students point of view) and for organizing the didactic material in a more effective way (from the teachers point of view).

References


Appendix

The questionnaire used to evaluate the first version of Hypercalculus contained the following questions:

- Did you use a hypertext before?
- Did technical problems ever divert your attention away from the contents while you were using the hypertext?
- Did you find the organization of the contents immediately evident?
- Did you ever lose the sense of direction inside the hypertext?
- Did the function of all the buttons appear evident to you?
- What kind of difficulties did you experiment during the use of the hypertext?
- What are, according to you, the advantages of using a hypertext instead of a book which contains solved exercises?
- Is the language clear and comprehensible?
- According to you, do the proposed exercises help the learning of concepts?
- What were the difficulties you met with in learning calculus?
Remote Tutoring: What we Learned by a Practical Experience

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Abstract: This paper summarizes a videoconferencing remote tutoring experiment run at Politecnico di Torino, Italy. After the description of the requirements and the design of the experiment, we interpret the results both from the technological and the cognitive perspectives. Finally, starting from the evaluation of the case study, we outline the design of an improved software and hardware configuration which overcome the assessed problems and enhances the positive features.

1 Introduction: Remote Tutoring versus Remote Teaching

Recent years have seen increasing interest in computer mediated distance education and many researchers have presented their results in this field [Eschelbeck, 1995] [Greenberg, 1995] [Jones & Knezek, 1995]. Proposed solutions range from the use of electronic mail to the one of multipoint live videoconferencing [Abel, 1990] [Rettinger, 1995].

In this work we present our experimental results on remote tutoring, a complementary aspect of remote teaching, which however presents different and challenging features. Remote tutoring is highly interactive and presumes a dialogue with the students in which the phases are balanced and often unstructured. The tutor should be able to propose questions and exercises and solve them with the contribution of the students; on the other side, students should be allowed to interrupt and ask for further explanations, and should have the possibility to work on the problems on their own and to present the results to the tutor.

For these reasons unidirectional media, such as video tapes, are inadequate, and asynchronous ones, such as electronic mail or discussion groups [Sproull & Kiesler, 1991], are not very effective since they introduce a delay between the dialogue phases and they lack immediacy.

2 Requirements for Remote Tutoring: our Case Study

Politecnico di Torino, in collaboration with other Italian universities, started four years ago a program of higher education distance learning based on the broadcasting of prerecorded lessons and on tutoring sessions. The latter used to take place, so far, in a number of sites spread all over the Italian territory, and involved the physical presence of the tutor.

In this distance education context we designed and developed a pilot remote tutoring experiment connecting Politecnico di Torino with one of these sites, the town of Alessandria, 90 kilometers far from Torino. Aim of this experiment was assessing the feasibility and the effectiveness, both from the technical and cognitive points of view, of this approach, in order to apply it on a larger scale.

The selected pilot course was a computer science one, about CPU architectures and assembly programming; a small number of students (ten) was involved. Major requirements of the experiments were limiting investments, using existing commercial technology, and providing video, audio and data interaction.

Besides that, no Internet connection was available in Alessandria, thus preventing us from the use of assessed computer supported cooperative tools like electronic mail, network based distributed applications, electronic discussion groups.
3 Remote Tutoring System Design

Given the requirements of the case study previously specified, we chose the configuration explained in the following. We organized two rooms, one for the tutor and the other for the students, linked through a Basic Rate Interface ISDN connection (128 Kbit/sec). Such a connection allowed us to exploit the ITU H320 standard technology.

The tutor site consisted in a H320 workstation equipped with a camera, an audio unit and software for application sharing. The camera had manual control for focusing and zooming, and was held by a rotating support which enabled us to frame either the tutor or a document placed on top of the desk. The audio unit contained a digital signal processor which performed echo cancellation: in this way handsfree operation was possible with acceptable audio quality. Programs running on the tutor workstation could have their interface replicated in the remote site through the application sharing software, and vice-versa.

The students site had a slightly different configuration: the video signal coming out of the H320 workstation was replicated on three monitors in order to have no more than three people watching at the same screen. Two more PCs were available for making the exercises assigned during the tutoring session. Handsfree operation with automatic gain control allowed each student in the room to communicate directly with the tutor without approaching the workstation. The sharing of students application was possible only via the H320 station. A fixed position camera provided to the tutor with an overall view of the students room.

Even if we recognized the importance of reciprocal eye-to-eye contact, achievable through a simple video device arrangement [Buxton, 1992], this solution was impracticable because of the one-to-many communication paradigm.

The design originally conceived the use of other devices, such as scanners for hand-written material input and a second camera on the students site which could be remotely controlled by the tutor. These tools were not employed in order to reduce the investment costs.

4 Evaluation of the Experiment

The experiment consisted in 16 hours of remote tutoring interleaved by fourteen hours of vis-a-vis tutoring, leading us to the following considerations, drawn by both our observations and by questionnaires and interviews with the students.

1. The students noticed minimal difference in learning remotely explained subjects and on-site ones if these were previously prepared by the tutor with slides, drawings, documents and programs.
2. The lack of suitable input tools for hand drawing made unexpected questions difficult to deal with; the chalkboard still appears the most effective tool in this situation.
3. The poor definition of the video channel made on the other side ineffective the use of the camera for framing a real chalkboard.
4. The preparation of remote tutoring sessions required therefore more work for the tutor, since she had to build a good model of the students to foresee the largest number of possible questions.
5. The use of shared applications for displaying documents and slides, and for writing, compiling and running programs proved to be very effective; this was mainly due to the non-intrusive action of the tutor, who could silently observe the students and interact with them only when needed or asked.
6. The physical layout of the equipment, with multiple instances of the video source and a single audio source, led to the lack of a focal point of attention for the students, which had the video medium in front of them, and the audio one in a different direction.
7. The camera framed the whole students room, therefore facing some students and showing the profile of others; this resulted in a limited feedback for the tutor. In addition, the narrow bandwidth and mono-aural audio channel made difficult for the tutor to easily locate a student asking for her attention.
8. Shared applications sometimes hid the remote camera window thus preventing the tutor from looking at the students: this was particularly unpleasant for the tutor during explanations, since she had no visual feedback about the comprehension level of the students. This problem was overcome in part when the students learned to confirm their understanding or to ask for further explanations, avoiding long silent intervals.
9. The high cost of digital telecommunications in Italy makes this approach economically ineffective for medium and short distances, unless a multipoint conference unit is employed to assist at the same time students located in different places; in this case the telecommunication cost overhead balances the reduced cost of the personnel.

10. The cognitive overhead due to teletutoring was negligible according to the 50% of the students; the others found the remote sessions more tiring.

11. Technical problems during the remote sessions were infrequent, and the students did not consider them as a relevant disturbing factor.

5 What we Learned by the Experience

Looking at this experience under a critical perspective, we intend to highlight some major points.

Three media were available for the remote interaction: audio, live video and shared application. Each of these media, if alone, does not carry enough information to be effective in remote tutoring. Both live video and shared application involve visual perception, and if displayed at the same time can provoke cognitive overhead. The pair audio-shared application proved much more effective than the audio-video one, because of the specific content of the course (Assembler programming) and because shared applications such as whiteboards, slide shows, word processor documents do not suffer the quality loss of live video, and are displayed on the remote screen exactly as the original ones.

The quality of the audio medium is fundamental; care should be taken for the choice of the devices and their physical layout, trying to reduce the influence of environmental noise. The use of echo cancellation devices is a major requirement for handsfree operation as well as the employment of an audio equalizer to limit the microphone sensitivity to undesirable frequencies.

The tutor is the one who benefits more by live video: the non-verbal feedback given by this medium is psychologically effective, since it helps in tuning the didactic activity. She could take advantage of a remote controllable camera, capable of framing either the whole classroom or a single student's face; this would give extra non verbal feedback when interacting with a specific person.

An important requirement which emerged is the need for a friendly input device for fast sketching of drawings and mathematical formulae; a graphical tablet with a pressure sensitive stencil could likely fit this purpose. In this way unforeseen explanations become easier and more effective. Although the camera can be used to frame a sheet of paper on which the tutor can write, partially overcoming the problem, the poor definition of the video reduces the effectiveness of this approach.

Students attention should converge on a single physical point, from which both the video and the audio signals originate. This could be achieved through an overhead projector which displays the image of the tutor on a large screen, surrounded by loudspeakers; the camera should be placed immediately above the screen.

Point to point connection leads the tutor to a deeper interaction level with the students who directly operate on the remote H320 station: the easiest solution to this problem is a frequent alternation among students; the most effective one is the employment of a multipoint conference configuration.

6 Perspectives: an Improved System

The evaluation of the results of the remote tutoring experiment gave us some indications on the direction of the possible improvements of our system in the imminence of a new experience.

Given the technical characteristics of the H320 standard, we can logically represent each end of the remote connection as a set of three input and three output plugs: the video, audio and data streams. We can therefore describe what we consider an improved system in terms of the devices connected to these plugs.

6.1 Tutor Side

*Video in:* a videocamera located on top of the tutor screen.
Video out: an overhead projector which displays the remote video signal on a large screen behind the tutor monitor; this overcomes the assessed problem caused by full screen shared applications which hide the remote video window leading to a loss in feedback.

Audio in: a high fidelity microphone.
Audio out: a high fidelity loudspeaker.

The audio subsystem should be integrated with an echo cancellation device; it should have as much bandwidth as possible to improve the overall quality, and it should possibly be stereophonic, to help the tutor quickly identify the remote speaker.

Data in: shared application data, in conformity with the T.120 family of standards for multipoint operations.
Data out: remote shared applications data.

The data subsystem is driven by the tutor personal computer which is interfaced with a graphic tablet, a scanner and a printer.

6.2 Students Side

Video in: the output of a tutor controllable video multiplexer which selects either a camera framing the whole room or one of the videocameras located on top of each student screen.
Video out: an overhead projector which displays the remote video signal on a large screen in front of the students.
Audio in: the output of an audio mixer connected to high fidelity microphones, one per student.
Audio out: the input of a remote controllable audio demultiplexer driving headphone sets, one per student. The tutor can either talk to everybody or choose a restricted group of students thus allowing individual interactions.
Data in: shared application data, in conformity with the T.120 family of standards for multipoint operations.
Data out: remote shared applications data. Each student operates on an individual personal computer which is interfaced with a graphic tablet, a scanner and a printer.
Application sharing should be possible either in point to point or in multipoint operational mode, thus allowing both individual and group tutoring. This conceptual configuration can be physically implemented by using, on the students side, a device that we here call “H320-server” that bridges the ISDN line and the local area network to which all students PCs are connected.

The server splits incoming data into three streams, converting the video and audio ones into the analog format and re-transmitting data onto the LAN, either in unicast or in multicast operation mode. The device also performs the opposite operations on the reverse direction, sampling the incoming analog video and audio signals and assembling the resulting data streams with data coming from the LAN into the ISDN stream.

Finally the H320-server controls, on behalf of the tutor, the video multiplexer and the audio demultiplexer. No special hardware other than a standard H320 board is necessary on the tutor side.

This solution is better than the one we used in our experiment because it allows both group and individual tutoring. Moreover it requires lower investments than the use of a network of H320 stations connected to a multipoint conference unit.

Here we assumed no more than ten students attending each remote tutoring session. In addition to these sessions, other asynchronous communication tools for tutoring can be used, such as electronic mail correspondence, ftp files exchange and network information retrieval tools like WWW or gopher; the last two can be employed, for example, to make didactic material available to students.

7 Conclusions

In this paper we presented the outcomes of our experience in remote tutoring, moving from the description of a real experiment to the design of an improved telecommunication system for tutoring.
According to our observations, telecommunication and videoconferencing technologies make real time remote tutoring feasible, but not optimal yet. In spite of the number of media available, remote tutoring is still not equivalent to on site presence; lack of eye-to-eye contact, slow video refresh, monoaural narrowband audio signal, are all factors which limit the direct engagements among the parts.

Multipoint conference technology is still under development as far as data application sharing is concerned, and this is an obstacle for real individual tutoring.

Our experience suggests that both students and tutor should develop a specific behavior to take full advantage of computer supported remote communication; in particular students should learn to provide extensive audio feedback in place of the more intuitive visual one, which is made less effective by the poor video definition. The tutor, on the other hand, should learn a different way of organizing the didactic material in order to use the communication tools at their best.

Major economical benefit can be expected as soon the deregulation policies will become a reality, and competition among telecommunication providers will reduce long distance call costs.

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Abstract: multimedia can provide a means of communications that is very close to talking to a real person. Multimedia should be interactive to give the user as much control over the choices that s/he needs; however, most of the multimedia software is not interactive and the controls are similar to the standard video tape controls. This paper discusses issues in interface design that allows interactivity and gives the user control so s/he can make meaningful choices.

When you need information, where do you go? Talk to an expert in the field. This is the most efficient way to get what you need. You can ask the questions you need answered. If an answer confuses you, you can ask for clarification. However, it is not always possible to find an expert when needed. An alternative is to search for books dealing with the subject. In this case, you may need to read one, ten, twenty or more books to get what you need. You may get lucky and recognize the answer you are looking for in a table of contents or index. Often, however, you will have to read the books from beginning to end to find the information that you need.

Non-Linear Versus Linear

Talking to an expert is non-linear, there is interaction between you and the expert. Most of what the expert says to you is in response to what you have asked. What the expert says to you is different than what he or she would say to someone else, because you have different questions. A book on the other hand is linear. The author has gone to a lot of trouble to place the information in a meaningful sequence. The author is expecting you to read the material in the same way that it was written. There is no interaction between you and the author. The author says the same thing to every reader because what he or she says is in no way affected by your individual interests and questions.

Multimedia software can be non-interactive or interactive providing some of the expanded bandwidth of talking to a real person. Some times it can be better than talking to an expert, providing pictures and video of actual phenomena and places. Multimedia is not necessarily interactive, but it should be. Without interactivity a multimedia title can just as easily be delivered on a video tape as the computer. It is a waste of the computer to deliver a linear presentation on the computer monitor because the power of the computer is more in manipulating the information than in its ability to display moving images on the screen [Fisher 1994]. Unfortunately, very little of the multimedia that is currently published, is truly interactive.

Meaningful Choices

To be interactive, the software must put the user in control and s/he must be able to choose what to see or what to do at any time. However, true interactivity entails more than just giving the user choices. Choices have no meaning unless the user is also given a context in which his or her choices matter and sufficient input to be able to make a meaningful choice. Consider, for example, the interface shown in Figure 1.
You are asked to make a choice, and are offered three blank buttons. Which one do you choose? On what basis would you choose? We posed this question to a class recently and one student answered, "Who cares?" Exactly. Interactivity assumes that the user has choices, but those choices have to be meaningful. We have to have good reasons for making any particular choice, and the interface must provide us with enough information to apply those reasons. The example in Figure 1 is an extreme case, but functionally similar interfaces are rather common.

Where in the World is Carmen San Diego is a popular example of interactive multimedia for education. Consider, however, a typical interface in the program. You have just landed in a country. Your goal is to try and find a criminal. The interface is offering you a choice of four activities that might help you accomplish your goal: talk to a tourist, check the church, ask the student, call Joe at 635-5555. At first glance these seem to be meaningful choices. However, it turns out that the text of these choices has no relationship to the clue you will find when you click on it. At least there is no relationship that the user is expected to understand or infer. More importantly, it does not matter which text you click on. You are expected to click on all four before leaving the county, and it apparently makes no difference what order they are clicked on. In other words, functionally this interface is identical to the interface in Figure 1, except that it offers an extra meaningless choice.

Interface Design

As users, the perfect interface will provide us with everything we want (stated in our own terms, one click away), nothing we don't want, and no surprises.

Everything we want: the interface should provide us with an easy way to get anything that we might want, assuming that the software can provide it. Of course the software should be able to provide us with anything that we want. By "an easy way" we mean that we should not have to work hard, mentally or physically, to find what we want. Mentally we should not have to work hard. Choices should be stated in our terms, not the computer's terms. Otherwise we have to translate what we want into terms that we think the computer can understand, what Norman refers to as the gulf of execution [Norman 1986]. Physically we should not have to work hard. We don't want to click through six levels of hierarchical menus to get to the piece of information that we want.

Nothing we don't want: on the other hand, we do not want any clutter. We don't want to have to search through a lot of choices to find the one that we want. We certainly do not want the screen cluttered with choices that we would not want.

No surprises: we don't mind if the program surprises us, especially if it is a game or entertainment. But the interface should not surprise us. We should have an intuitive idea what any button will do, before we press it.

Too Many Users, Too Little Time

Designing this perfect interface is, of course, quite difficult. There are trade-offs between these ideals (for example, an uncluttered screen vs. everything one click away). We will have different needs, goals and intentions as we go through a program. Even if the perfect interface could be designed for me, it probably would not be perfect for you. This is a problem since the goal of good interactive multimedia is to allow different users to approach the same content in a way that is meaningful for them. How do we design a human-computer interface that will at least be optimal for a wide ranges of users?

The first answer is: know your users. Make sure you identify who will be using your program, why they will be using program, the context in which they will be operating, etc.. Talk to them. Show them your designs and early prototypes [Rheingold 1990].

Given this knowledge of the users, the goal is to design an interface that will allow potential users to fulfill their intentions at any point in the program. If the users know what they want, this entails making it easy for them to map their intentions onto the interface. If the users do not know what they want, this entails making their options clear and providing them with enough information to make a reasonable choice.

In order to allow users in either of the above situations to make meaningful choices, the interface should offer options that are: distinct; non-ambiguous; from the user’s point of view; and cognitively manageable.

Distinct options: imagine that you want to buy something from an on-line shopping service. You access the site and are greeted by choices on buttons that read: buy or shop. Which button do you click? Both buttons contain verbs someone might use to indicate that they are buying something, so what is the difference?

The options that the designer intended to provide are:

1. look at pictures of available items (what the designer thought of as "shopping");
2. go directly to the order form (what the designer thought of as “buying”).

The designer's interpretation of these terms is certainly legitimate, and to any user that thinks just like the
designer, these choices will be reasonably clear. To many people, however, there is considerable overlap
between buying and shopping, and thus the distinction between the two buttons is not clear. Most users would
be able to figure out that buying involves actually making a purchase, and that shopping can be a little less
committal. It would still be unclear what would happen when each of these buttons were clicked, and it takes far
too much mental energy to figure out what the distinction might be.

The buttons were changed to read: browse and order. There is far less overlap between browsing and ordering.
The buttons refer to the same options, but for most people the choice will be much clearer, as will the resulting
action.

Non-ambiguous options: ambiguity can easily occur when icons are used. Consider the icons in Figure 2 from
an interface designed to allow users to search for information about shopping malls. These icons are supposed to
represent the different criteria by which a user can search. Looking at these icons, however, the user would have
no idea what those possible criteria are.

Fortunately this interface included text under each of the icons. The labels read, from left to right: Location,
Size, and Type. The text certainly makes it clearer. If you want to search for shopping malls by size, you would
click on the "computer" icon. The question is: do the icons add anything to the interface? Although each of the
icons could be interpreted as referring to a search, there is nothing to associate any of them to the specific
criteria.

Icons should ideally be non-ambiguous without text. If text is used, it should only confirm what the user already
thinks that the icon will do. Minimally, once the user has associated the icon with the text, the icon should from
that point on be clear. It is doubtful, however, that these icons will ever have independent meaning. If no good
icons exist for an action, plain text would be preferable.

From the user’s point of view: some users have problems with the buttons shown in Figure 3-a (from an on-line
magazine). By clicking "confirm order", is the user confirming the order, or is the user asking the computer to
confirm the order? When the user clicks “what do you think?” is the user asking the computer what it thinks, or
is the user notifying the computer that he or she wants an opportunity to submit their own thoughts? Would the
"feedback" button elicit feedback from the computer, or bring up an interface that allows the user to give the
computer feedback?

In each of these examples it is unclear who is doing what to whom. In the two buttons with pronominal
references, the references shift: the first person "I" in "How do I order this?" refers to the user; but the second
person "you" in "What do you think?" also refers to the user. The other two buttons have no pronominal
reference, the user has no way of knowing if they are requesting or taking an action.

The buttons in Figure 3-b make it much clearer what will happen when the user clicks the button. Not only are
these buttons more consistent and less ambiguous, but each is stated in the user's terms. In other words, if the
user is thinking, "I want to confirm this order," they would click the, "I want to confirm this order" button.

Cognitively manageable: imagine that you want to know about the city of San Diego. You access the web site
for San Diego and see the home page shown in Figure 4. Let's say that your specific goal is to find out about
United States International University (USIU), which button would you click?

How long did it take you to decide which button to click? You probably started at the top and read every button
until you got to "Universities and Colleges." Many searches, however, would require users to read ALL of the
button titles at least once, to decide which is most appropriate. For example, where would you click if you
wanted information on beaches? What if you wanted information on Lutheran Churches in San Diego? The problem is that a knowledge base such as the San Diego web site can contain thousands of pieces of information. Given a large database and a wide range of user needs, how do you provide quick intuitive access to the particular piece of information that a particular user wants?

Interface Approaches

The interface pictured in Figure 4 represents one approach to this problem. The thousands of pieces of information were divided into 30 categories. The interface lets you choose any one of those categories. We call this the Cockpit Interface Approach. Every category is right in front of you, just as every possible control and meter would be right in front of you in an airplane cockpit. Many programmers we have worked with tend to prefer this type of interface. Most normal users, however, find that the large number of categories creates an unacceptable search [Shneiderman 1992] problem.

A second approach is what might be called the Organized Cockpit. In this approach, every option would still be on the screen, but they would be organized to reduce search. The buttons in Figure 4, for example, could be organized so that each column had a common theme. If the columns were color coded and labeled, the number of buttons you had to search would be reduced. The most common organizational scheme is to alphabetize the options.

The third approach is a hierarchical interface (see Figure 5-a). This is similar to the Organized Cockpit, but here each subset of options is on a separate screen. Each screen thus offers a reasonable set of options, there is no search problem on any screen. The trade-off is that it now takes more clicks to get from the top to the piece of information the user wants. This also assumes that the options at each level are perfect, any ambiguity and the user may never find the desired information.

The fourth approach is the multiple view interface (see Figure 5-b). Similar to the hierarchical interface information is represented at the highest level as a manageable set of categories. In the multiple view interface, however, there can be multiple sets of categories at each level.
Imagine, for example, that you are looking for information about dogs in a multimedia database. The interface offers you the categories shown in Figure 6-a. If you are an educated adult, you would have no trouble deciding to click the mammals button. If you were a child, however, you might not be able to find dogs. In a multiple view interface the user could have the choice to browse the animal kingdom using the categories represented in Figure 6-b. A child would have far less trouble with this interface.

The fifth approach is the Search Field Interface. The user types in what they are looking for, and a search engine finds the information for them. While the interface design is simpler, appropriate search fields must be created. Users often prefer the Search Field Interface to a multiple-level hierarchical interface.

In conclusion, the perfect interface is quite difficult to develop and researching the users’ needs is an important phase in design. A good interface should offer options that are distinct, non-ambiguous, from the user’s point of view, and cognitively manageable. Users should be able to make meaningful choices in context. When handling large databases, different interface approaches should be considered to create intuitive access to information.

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Designing Effective Multimedia Programs to Enhance Teacher Problem Solving Skills and Cognitive Flexibility

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Abstract: Multimedia case studies are becoming more common in teacher education. This paper discusses the design of multimedia case study materials from cognitive flexibility theory and reports the results of the use of these materials in graduate education courses in two national field test sites. Findings and discussion are based on analysis of on-line user records, embedded computer-generated reports, and qualitative interviews from the two sites. Results include changes in perspectives, responses to design features of hypermedia-based case studies, and suggestions for implementation.

Introduction

Teacher education involves the development of knowledge, skills, and applications. The weakest link in preservice teacher education is the translation of knowledge and skills taught in methods classes to performance skills in the classroom (Rule & Salzberg 1988). Multimedia simulations afford an intermediary step for applying knowledge and skills through classroom-anchored scenarios. In simulations, learners must seek information, modify preexisting concepts, and utilize knowledge and skills in new ways.

Interactive videodisc technology has several characteristics which make it a powerful training tool. The videodisc has a large storage capacity for video, audio, text and graphics which can be linked to a computer program for instruction. When the materials stored on the videodisc are controlled through a computer program, these instructional materials can be accessed in an immediate and nonlinear fashion. In this way, the instructional process is dynamic, delivered efficiently, and individualized by learner input through the computer (Fitzgerald 1995).

Theoretical Framework

The constructivist view of learning asserts that knowledge is internal to the individual and constructed through interactions with the environment and through negotiations of meaning with others. Learning occurs when new materials are integrated within an individual's preexisting knowledge structure. Knowledge comes from experiencing problems in diverse contexts, sharing multiple perspectives, scaffolding, and cognitive apprenticeships (Nelson 1994). Hypermedia-based instruction must go beyond simply representing associations (knowledge representation); it must stimulate cognitive processing to construct meaning from those associations (knowledge construction). Key tenets in constructivism include personal experience, active exploration, multiple perspectives, and cooperative learning activities for communication and collaboration. A major problem in designing hypermedia instructional systems is to avoid merely presenting information, but rather, to foster learning through the interface design and interactive problem solving activities.
The design for this interactive videodisc program is based on Cognitive Flexibility Theory, one of the constructivist theories which emphasizes the real-world complexity and ill-structuredness of knowledge. "Cognitive flexibility" involves the selective use of knowledge to adaptively fit the needs of understanding and decision making in a particular situation; the potential adaptive knowledge assembly depends upon the availability of a full representation of complexity to draw upon. "Ill-structuredness" means that many concepts (interacting contextually) are pertinent to a specific case, but that their patterns of combination are inconsistent across case applications of the same nominal type (Spiro, Coulson, Feltovich, & Anderson 1988). The instructional approach utilized in this program strives to develop cognitive flexibility to enable the learner to construct knowledge based on complex and irregular situations. It focuses on the construction of knowledge structures and the use of that knowledge structure in problem solving.

A major difference in cognitive flexibility theory from traditional constructivist theory is the change in emphasis from developing a knowledge structure based on intact preexisting knowledge to flexible adaption of preexisting knowledge to fit needs of a new situation (Spiro, Feltovich, Jacobson, & Coulson 1991b). Such is the case in understanding and assisting children with emotional and behavioral disorders. While central concepts related to the child and situation must be considered, each case involves clinical and ecological differences which must be viewed, interpreted, and responded to differently from multiple perspectives. While the concepts and views of the problem may be well-structured—albeit different based on various theoretical perspectives—the use of those concepts and views in problem solving will be substantially ill-structured, leading to diverse solutions.

Instruction in ill-structured domains is different from instruction in well-structured domains where knowledge may be taught in compartmentalized units and later integrated. In ill-structured domains, instruction must focus on general principles and knowledge interconnectedness across a wide scope of cases or examples. Multiple representations are required to enable preexisting knowledge to be assembled flexibly on a case-by-case basis. Through this process, adaptive knowledge is developed and flexible knowledge structures are acquired. By drawing upon preexisting knowledge with cognitive flexibility, the learner is able to transform that knowledge and act upon a particular case (Spiro, Feltovich, Jacobson, & Coulson 1991a).

The Multimedia Program: Multiple Perspectives in Behavior Disorders

Description

The purpose of Perspectives on Emotional and Behavioral Disorders is to enhance problem solving skills of teachers who work with children with behavioral disorders. Each of the three cases includes an opening challenge scenario and supportive information presented via software controlling a Level III interactive videodisc. The case materials allow users to explore and practice the processes involved in serving such children by (1) observing children in a variety of situations; (2) "interviewing" their teachers and parents; (3) seeking information; (4) comparing and contrasting multiple theoretical views; (5) hearing "experts" discuss the cases; and (6) engaging in problem solving and planning activities.

Through the interactive case study approach, the learner is expected to develop a cognitively flexible understanding of the complex, multiple theories and approaches used in formulating intervention programs for students with emotional and behavioral disorders. The real life situations provide a micro-world for exploration. Each case study student represents a different severity level, e.g., mild to severe in regular classrooms and special settings. Within its hypermedia structure, user control is provided through the main menu and perpetually-active pull-down menus. The video and audio materials are linked to choices made via the computer program so that they may be accessed in different sequences and ways under learner control.

Once the learner enters his or her name, the Case Explorer screen appears on the monitor and the user starts exploring the case study materials. A variety of video, audio, and text-based activities are provided.

- The opening Scenario depicts a school administrator addressing two teachers regarding a youngster who is having difficulties in school and home settings.
- The administrator asks the teachers to Get Information by observing the student, talking with others with knowledge in the field, reviewing background information on the child, and then meeting back with
questions regarding the child's needs. This video-based scenario establishes the need to go through a problem solving process to consider a range of options and to synthesize information.

- The videodisc contains a database of information regarding the students in Student Records and substantial support material in Fact Sheets and Theoretical Perspectives.
- Users are able to view children in multiple classroom situations through Observation segments.
- Special terminology is hot-linked to a Glossary.
- A second audio track placed on the videodisc provides dialogue about the youngsters by Experts in the field of behavioral disorders. Photographs of the experts appear on the computer screen to provide a visual image of the speaker while the audio sound track is played.
- The program includes note-taking tools in My Notes for users to record observations, thoughts, and questions. These can be accessed by the user, either on screen in Read My Notes or through a printed hard copy; these notes provide an opportunity to document the user's progress through the program.
- Users write their own questions in Prepare to Meet to be discussed in a simulated case conference Attend Meeting.
- Users check the accuracy of the information gained through the Quiz option.
- When finished exploring the case materials, the user enters answers to the challenge questions in Make My Report.
- The notes, the amount of time the program is used, scores on the quiz, questions prepared for the meeting, report answers, and the user path through the computer program are all recorded on a floppy disk. These files can be used by the instructor to monitor each user's progress and to make instructional adjustments.

Implementation

The program was field tested in graduate courses in behavioral disorders at two locations. Data collected for analysis included on-line user records, on-line student reports, instructional material artifacts, and semi-structured qualitative interviews with users.

Site I

In a Mid-Atlantic state, the program was integrated into an on-campus course with nine graduate students. To obtain course credit, all students were required to complete the case studies on all three children featured in the program. Users worked independently in the computer lab on the case studies. No direct instructor supervision was provided but computer lab assistants and the instructor were available if help was needed. Following case exploration, class discussion groups were held during class time to simulate a planning conference for each child. Students submitted their floppy disks containing usage data and computer-generated reports; the instructor provided feedback on submitted work.

Site II

In a Midwest state, the program was set up at a juvenile detention center school for eight practicing teachers enrolled in an off-campus course. The materials were provided as an independent work station activity; these users were instructed to explore the materials to prepare for class discussion of the children. Following a brief demonstration of the program and equipment, users worked on their own time at the work station during after-work hours. No instructor or troubleshooting assistance were available. Users submitted their floppy disks containing usage data and computer-generated reports to the instructor for the purpose of evaluating the materials; no grade contingencies or instructor feedback were attached to the user records.

Results

User Records

Data collection routines were included in the software which appended archival user records onto a student floppy disk. Data collected for each user included date, usage time, and on-line responses to question prompts.

Patterns of Use
Significant differences were found between the two sites in on-line usage time. In Site I where the program was fully integrated into the graduate course, the average time of use equalled 5.04 (standard deviation = 1.80) hours for the first case study; 4.24 (standard deviation = 1.91) hours for the second case study; and 4.06 (standard deviation = 1.23) for the third case study. In Site II where users were asked to explore the materials independently as time permitted, the users spent approximately 45 minutes on one case study; only one user recorded 6 hours of usage.

Perspectives Changing

The on-line reports written by users in Site I were analyzed using a scoring rubric. Scores from the first case study were compared to scores for the third case study in order to measure change. All reports were scored blind by two raters; inter-rater reliability equalled 72% based on 17 disagreements and 43 agreements; only one disagreement was more than one point different. All differences were resolved prior to data analysis.

A "personal perspectives" score was given based on responses to the on-line question prompts: What is your perspective of this child's needs and how do you support this position? A significant difference was found on the "personal perspectives" comparison, no significant difference was found between scores for the first case and the third case. Using a paired t-test analysis, the mean difference equalled 0.2 on a five-point scale (score=2.0 pre compared to 2.2 post; p=.55). These moderate scores revealed that respondents select only one or two perspectives for the basis of their opinion and did not show much change in personal perspectives.

A "team synthesis" score was given based on responses to the question prompts: Who would you like to be on the team for this child and what views do your team members share? A significant difference was found on the "team synthesis" comparison between scores for the first case and the third case. The difference equalled 1.6 on a five-point scale (score=2.9 pre compared to 4.5 post; p=.002). The higher scores for a "team synthesis" revealed an awareness that multiple team members are needed to meet children's needs, that these team member's represent multiple professions, and that common agreement exists which goes beyond the beliefs of individual team members.

Qualitative Interviews

Two-and-one-half months following course completion, semi-structured interviews were completed with all students from Site I and six of the eight students from Site II. The purpose of the interviews was to evaluate the students' perceptions of the software and its use in the course. The interview included the following prompts:
1. Tell me something about your feelings when first using these materials; what were your initial reactions?
2. Did you have any problems using the materials as assigned?
3. How did your impressions of the materials change towards the end?
4. Could you reflect on what you learned from your experiences with this program?
5. Do you have any advice for the instructor for implementing these materials?

A phenomenological approach was used to analyze the data (Glesne & Peshkin 1992). The interviews were transcribed and read multiple times. Four of the interviews were read in group sessions by the researchers. Notes were taken during the reading of the transcripts about possible themes and idea units. The second author segmented the transcripts into idea units and these units were sorted into categories. The idea units and categories were independently applied to three interview transcripts; discrepancies were resolved and the remaining interviews were subsequently segmented and sorted by the second author. Analysis of the data produced four themes.

The Program Was a Good Way to Learn

Most participants expressed enthusiastic praise for the use of the program to learn about children with behavior disorders. The praise ranged from the very general to the very specific. For example, one said, "I thought it was excellent. I've never seen anything like that before in any of the classes I've been in...I think it will be helpful for most students to go through it." The videos of the children were valued as opportunities to observe specific behaviors in an informed way. The voices of the experts, giving insight into the children's behavior from different theoretical perspectives, were highly regarded by all. The note-taking feature, the planning meeting, and the quiz were all singled out for praise. Participants also regarded the hypermedia aspects of the program highly. They felt that the ability to interact actively with the different media of the program was
beneficial. Most of them found that they enjoyed the ability to choose their own path through the materials, the individualization, and the learner control.

Comparisons were made to learning through this program and learning through traditional forms of instruction. The program was generally viewed as more meaningful and more interesting than text. It was seen as an aid to visualization and it made the abstract theories presented in the text easier to understand through concrete examples. When comparing it to lecture, discussion, or classroom observations; it was considered superior for allowing you to "go at your own pace" and to "go over what you might have missed." Participants regarded the program as a good preparation for teaching. As one stated, "I feel like I can do better in the classroom now as a teacher. I feel like I have had hands-on experience doing an assessment. I feel like I can write up a report better. It is actually like you're in the classroom—you're right there—you are doing the observation."

Users Experience a Variety of Problems

The use of level III interactive videodisc technology was a new experience for all participants. At both sites, they experienced some problems using the software and equipment. Most frequently cited problems were loading and getting into the program, problems with using the note-taking part of the program, and problems with access and scheduling of the videodisc equipment.

Several students at Site I found that access to the computer labs in terms of their schedule or their travel time was problematic. The further their distance from the campus, the greater the problem. In Site II, participants often attributed their problems to their own lack of computer experience or knowledge. One difference between sites was the perception of the locus of the problem. If notes were lost from the user's disk in Site I, these participants attributed their problems to the program or the disk, while at Site II, participants often attributed their problems to their own lack of computer experience or knowledge as expressed by one, "At times it was terribly frustrating—again, it was just my ineptibility with the computer."

Anxiety and Frustration During Initial Program Use

Most participants said they felt stressed while beginning to use the technology. At Site I, they expressed fear of failure and fear of being overwhelmed by the demands on their time. All participants in Site I made the transition to feelings of comfort and confidence, as voiced by one, "I was indifferent and worried or anxious in the beginning that it was something over my head. But at the end I was very competent—or I felt very confident. The more experience I got the better."

At Site II participants initially expressed frustration at being unsuccessful at their first attempts to using the program. Here there were many more expressions of fear of using computers and frustration during computer use, as expressed by one, "I'm not a real computer literate anyhow, and the first night I went to work by myself it took me...35 minutes just to get into the program. I was real frustrated with it—terribly frustrated with it." This frustration frequently continued with further computer use; problems cited were navigating the program, note-taking, and confusions over the instructor's requirements for using the program. Site II participants expressed as much frustration at the end of their time using the program as at the beginning.

Users Give Advice for Solving Problems

The most common suggestions included to make the key words easier to identify by providing a list of key words and to provide additional assistance or training to those who have little computer experience. Suggestions on modifying the software included to provide case studies on older students, to make it easier to navigate the program, to speed up the program, and to provide more background on the students. Suggestions for instructor implementation included giving specific directions on operating the program and having someone available during program use to answer questions and solve problems.

Discussion

The results indicated that graduate students were positive about learning through interactive case studies. Users found the materials and interactive learning experiences worthwhile, valued the hypermedia design, and felt the materials were more meaningful than traditional forms of instruction involving textbooks, lectures, discussions, and classroom observations. A content analysis of reports written by the users indicated they did not alter their
personal perspectives about meeting the needs of behaviorally disordered students, but did reveal a significant change in their understanding and synthesis of multiple perspectives and team roles.

As examination of the data concerning problems using interactive videodisc technology found differences between the two sites. At Site I, participants characterized their problems as minor and felt the instructor resolved difficulties quickly. These users experienced some initial anxiety when using the materials but developed confidence with further program use. At Site II, the participants experienced frustrations using the software and never felt a sense of competence using the program. Records indicated these users spent inadequate time on the case studies and failed to complete the on-line activities. They attributed problems to the lack of on-site technical support, confusion over requirements, and their own lack of computer skills.

Further research is needed to evaluate the impact of instructor skills to teach with new technologies, technical support, equipment availability, prior computer knowledge and experience of users, and user anxiety and persistence. Multimedia case studies have the potential to provide a bridge between knowledge acquisition and application, but their effectiveness will be severely restricted by ineffective methods of implementation and inadequate support for new users.

References


The Evaluation of a Distributed Multimedia Foreign Language Learning System

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Abstract: This paper gives an account of the evaluation of a distributed multimedia foreign language learning system. An overview of the system is given and the user trials are described. A complementary mix of quantitative and qualitative techniques is used. An outline of the scope of results obtainable from such methods is given.

Introduction

The Institute for Computer Based Learning at Heriot-Watt University had the remit of evaluating a distributed multimedia foreign language system in the context of a large scale RACE funded European project - R2115 - called HIPERNET: HIgh PERformance NETworked multimedia for distributed language training.

The HIPERNET Project

The HIPERNET project developed an integrated networked multimedia system for distributed language learning by remote users across the city of Cambridge. A Gigabit Asynchronous Transfer Mode broadband network was installed. User trials of the application were conducted in October and November of 1995.

HIPERNET was a vertically integrated project, addressing all aspects of the system from the application software to the ATM-based Gigabit optical networking. It was strongly applications driven, with the end-users formulating a comprehensive requirements specification against which the system was designed.

Rationale

The assumption is that collaborative task based learning is an appropriate paradigm for foreign language teaching. Tasks are used to motivate the student to make effective use of the available learning tools, including the multimedia material. The tasks incorporated into the system require the students to show evidence of communication skills as well as topic related vocabulary. This encourages collaborative learning and the use of role play: for example the specific skills and verbal expressions needed to take part in a telephone conversation.

The role of the HIPERNET system is to facilitate this by providing appropriately structured multimedia course materials, and by allowing videoconferencing between pairs of students, and between student and adviser. Thus the specification of the system means that learners need access to multimedia resources and to each other over the network. The result incorporates servers of course material, video and sound together with real time video, audio and text communication tools.

Evaluation

What we want to know is whether the use of the system can provide for distance learning the quality of environment offered in a face to face teaching situation. Are, for example, current technical limitations so great that they prevent this from happening?
Although we are using some statistical comparisons, the main thrust of the evaluation is to understand what is going on. Thus we are collecting both quantitative and qualitative observational data. There is assessment of the degree of change on various criteria through direct measures, in addition to an ongoing series of observations. Through these we hope to highlight incidents and events of significance to contribute to the understanding.

Specific questions to answer include:
◊ Is the system successful in facilitating students' learning of French?
◊ How useful are the various features included in the system?
◊ How does collaboration using videoconferencing compare with working face-to-face?

The rest of this paper addresses the functionality of the system (Section 2); the user trials (Section 3); and the results obtained (Section 4).

The HIPERNET System

Tasks

The two tasks incorporated into the system involved the role-play of simulated business situations. These required the participants to be familiar with specific aspects of French business culture: in one case the Minitel information system, in the other the facilities for encouraging the setting up of commercial companies in the Nord Pas de Calais, and Lille in particular. The participants were to prepare the role-play for presentation to French teachers/assessors, who might also assume roles if necessary. Description of the task requirements are available to the users on-line. Each task has links to component sub-tasks, and these have further links into the course material.

Material

The material to support the fulfilment of the tasks is based on an existing multimedia course [King 1993]. Appropriate sections of the text, audio and video were prepared for computer presentation, with links between related sections.

Integrated with this there is a (prototype) multimedia dictionary. This consists of 1000 blocks of words, selected from the course book's glossary of around 3000, together with some specialised vocabulary from the book excerpts included in the HIPERNET system. A block is a word sometimes associated with examples of usage, or some of its different forms. Each block may be listened to, pronounced by a native French speaker, and some also have graphics or short video clips to illustrate them.

Communication Tools

In addition to standard online help facilities, users have the opportunity to communicate with an adviser, or with any fellow student who is currently logged in, unless they have specifically indicated that they wish not to be disturbed. Videoconferencing, and the related audio and text connections, thus have two main purposes: as a help-line, and as a tool to facilitate collaborative learning. Users may, for example, agree on separate subtasks to contribute to their joint mastery of a task, or the link may be used as a vehicle for rehearsing their presentation.

Workstations are situated at three separate sites, and there is an “adviser” workstation at a fourth location. During the system trials each student was paired with another at a different site, so that communication via the videoconferencing, or the text talk, was essential for their collaboration.

User Interface

The user has several routes into the system: via one of three versions of indexed course material (text, audio and video), via the task choice screen, where the chosen task leads to appropriate subtasks, or by picking up where
they left off at the previous session. To enable this, entry to HIPERNET included a log in process whereby the
student might be identified to the system, and a minimal log of student activity was maintained.

The display is potentially very complex, as it has to allow not only for the presentation of various teaching
elements, but also for the communication between student and student, and between student and adviser. There is
also the need to navigate between links, and to return to previously visited course elements.

User Trials

Six weeks were available for the user trials. Various factors had conspired to prevent planned pilot and usability
testing from taking place, so there was a need to monitor the ease of use and stability of the system as well as to
assess its effectiveness.

In order to gain as much understanding as possible of the learning processes involved, qualitative measures were
used as well as quantitative, and many of the learning sessions were observed or recorded using techniques
described below.

The subjects for the trials were students at the University of Cambridge, recruited via posters. The expressed
motivation to take part in the trials was mainly to improve their French. They also received a small payment for
participating in the study, and some showed an interest in the technology involved. Emphasis was placed on co-
operative evaluation: that they were regarded as fellow evaluators as much as users.

Students were timetabled in pairs, on the basis of their availability. These pairings were then confirmed, on the
basis of questionnaire data, as being between partners at an equivalent level of French experience. Although a
“real” HIPERNET system would not involve external timetabling of users, such timetabling was essential here to
ensure that the needs of the trials would be met.

Quantitative Techniques

It seemed unlikely that six weekly sessions would result in a measurable increase in French proficiency, other
than, perhaps, such things as task specific vocabulary. Nevertheless before and after ratings of various measures
were obtained from French teachers and from the students themselves. This did yield a significant result in
confidence in speaking French (see Section 4).

“Control condition”

Each pair was given one of the two tasks built in to the system to prepare, over a period of three weeks, for
presentation to the French teachers as a role play exercise. As a control for the effect of computer mediation, the
students spent three of the six week trials using HIPERNET, and the other three weeks under a no computer
condition. Under this condition students were presented with the relevant course material: the book, the audio
tapes, the videos and the printed task. The videoconferencing in HIPERNET was replaced by having the students
work in the same physical location. This allows direct comparisons with the computer mediated version of
HIPERNET, in terms of quantitative ratings, and, more importantly, as a basis for introspective comment by the
students.

The two tasks and two designs permit a balanced repeated measures experimental design, although the focus of
the evaluation is not primarily on the comparisons that this affords, but rather on understanding aspects of the
HIPERNET system and its use.

Assessor Ratings

The assessors were staff at the Cambridge University Language Centre. Assessor ratings on three factors:
fluency, pronunciation and grammar, were obtained for each subject at three points during the trials. The first
occasion was an initial interview, and the other two were the presentations themselves. The criteria for these
ratings had been developed in the context of another project [see Little et al 1994]. A fourth factor, confidence ,
was included in the hope of capturing some improvement in French despite the relatively short exposure to French learning materials that was offered to the subjects. The criteria for the confidence measure primarily involved eye-contact and repair strategies. Confidence in achievement of detailed learning objectives has been used before [see Draper et al 1994], but here the measure was of a more general nature with the intention of seeing whether the exposure to a specific task had had an effect on more than the specific vocabulary and concepts involved, and perhaps made the students more confident in communicating in French generally.

There were also overall ratings for the presentations given by the subjects in their pairs after three and six weeks. For this the criteria included: content, appropriate language, organisation, and presentation skills.

User Ratings

The assessors' confidence ratings were complemented by the users' own at the beginning and end of the trials. They were given a series of seven hypothetical tasks, ranging from booking a hotel room to 'phoning a plumber, and asked to rate their confidence in carrying these out on a five point scale that ranged from “No problem” to “No way!”.

User ratings were also used to give feedback regarding the stability and ease of use of the system. After each session they were asked to fill in a feedback form that included a record of the number of system failures, and a rating of navigability on a five point scale from “No problems” to “Very frustrating”.

Finally the subjects were asked, as part of a final questionnaire, to rate the usefulness of various features of the HIPERNET system, again on a five point scale, this time from “Very useful” to “Quite unnecessary”.

Time-lining

Time-lining was used to structure some of the observation of the HIPERNET learning sessions. There is a theory that people spend more time using features of a system that are the most “acceptable” in terms of usefulness, usability, and making work easier [see Collis and Verwijs 1995]. During the trials over 55 hours of use of the system were observed in this way, taken from 64 student-sessions. Occasionally both ends of a collaborating pair were simultaneously under observation. For each five minute period all activities were noted. More than one activity may occur at the same time, for example reading a text while listening to the audio version, and several activities may occur consecutively during each five minute time slice.

Qualitative Techniques

We encouraged the subjects to give copious feedback on the system so as to take advantage of their insight. Questionnaires, feedback forms and interviews were used, and there was recording of sessions to further complement this.

Questionnaires and feedback forms

An initial questionnaire was used to facilitate timetabling, and to obtain a self-rating of confidence. Other than that, all session feedback forms and questionnaires that the students filled in had space for comment wherever there was a rating, and included open-ended questions.

The final questionnaire, in particular, asked for comments about actual and potential features of the system, as well as ratings of their usefulness. Students, who by that time had experienced both conditions, were also asked to compare videoconferencing with working face-to-face.

Interviews

Structured interviews were administered after the first presentation, i.e. three weeks into the trials. All the students were asked how they went about preparing the task, and those who had used HIPERNET were also
asked about videoconferencing. Those who had not yet used the system were asked what they expected of it. This was partly so that their imagination was not restricted by any limitations in the actual system.

Screen capture

About half the HIPERNET sessions were recorded using screen capture. This involved intercepting the VGA output to the monitor so that it was captured on videotape as well as displayed to the user. Also the sound output of the computer was mixed with input from a microphone attached to the subject, to be fed in to the VCR at the same time.

Such recording may be used as the basis for time-lining, thus freeing the observer. It may be used for reference, to answer questions about the use of the system for which specific data was not collected at the time without needing to repeat the trials. Finally it may be used to illustrate the use of the system in discussion.

Screen capture is less obtrusive than subjecting the students to being videoed while using the system, and produces pictures of good quality and without flicker.

Videorecording

Initially some sessions were captured using a camcorder with similar motivation to that of the screen capture. This was not promising though, because of the flicker on the screen picture, and because, when videoconferencing, the voice of the distant student was not captured as the local student had to wear headphones to avoid problems of feedback.

The students' initial interview and presentations were videorecorded both for possible future micro-analysis and for immediate confirmation of details of performance.

Results

As the final stage of a very complex project one overall result is that the trials succeeded in demonstrating the delivery of a working system. Problems of stability, and the unavailability of the adviser workstation for much of the time, may unduly have influenced the detailed results. Nevertheless there was much useful feedback, pointers to areas of future work, and confirmation of the suitability of the evaluation techniques used.

In answer to the direct question: “Given a HIPERNET system that did not crash, and a traditional system with CDs, videos, book and dictionaries, which would you prefer to use to learn a foreign language?” 18 students, after experiencing both conditions, voted for HIPERNET, and 6 for the traditional methods.

Quantitative Results

Although there was indeed no discernible improvement in French performance with regard to the measures of pronunciation, grammar and fluency, there were two comparisons that yielded significant differences: the assessor rating of confidence improved over the no computer condition, and the self-rating of confidence improved overall. Despite the improved confidence rating in the no-computer condition there was no difference between the two conditions in terms of the presentations marks, suggesting that the videoconferencing proved an adequate substitute for face-to-face working on this occasion.

The answer to Question 1 is thus “probably”, as, although we do not have a measurable improvement in assessor ratings, it is quite possible that this could be because the measures are not sufficiently sensitive, and the increase in perceived self-confidence is evidence to support this.

It could be that the instability of the videoconferencing, which was in many cases an obvious problem with sound disappearing unpredictably on occasion, and difficulties in making connections, led to the students communicating less well under the HIPERNET condition. The high level of motivation of the students may have overcome this problem for the purpose of the presentation, but some reticence in communicating in French
would remain. There may be some other explanation. An important observation is that it is hard to separate out the effects of the system and those of the system's performance when there are problems of stability.

The results of the time-lining, viewed as percentage of time spent using the various features of the system, and seen in conjunction with student comments, reveal a common cycle over the three weeks: the first week is spent exploring the material and the parameters of the task; the second concentrates on defining the roles and information to get across at the presentation; and the third session is the occasion to rehearse the presentation. This follows Collis' "champagne glass" analogy [Collis and Verwijs 1995] for task fulfilment. The first, exploration stage, is the broad cup of the glass; the second, focusing, stage, the stem; the third, consolidation, stage, the foot. It seems here that it is the usefulness of particular features in a system, rather than their usability that determines their relative use; for example students would persist in attempting to videoconference despite being fully aware of the potential frustration involved.

The student ratings of HIPERNET features were mostly strongly positive, but their opportunity to comment contributed to our understanding of the significance of the individual ratings. This provides the basis for the answer to Question 2 on the usefulness of the various system features. It is not appropriate to go into the detailed results here. In general the intuitions of the teachers were justified and further insight into both the approach in general, and into aspects of the interface, were also given.

Qualitative Results

The feedback through interview and questionnaire confirms, and to some extent explains and complements, the ratings and measures obtained. The students' introspective accounts of videoconferencing vs. face-to-face are particularly illuminating. To illustrate this, a brief summary of the videoconferencing feedback is given here. It provides part of the answer to Question 3:

Not only was videoconferencing adequate for the purpose, but some actual benefits were perceived: a student can work alone, without distraction and without taking their partner's needs into account; as the connection is not always there, the interaction is more focused; it is "fun". Problems included: lack of eye contact; physical inconvenience; effort to make contact; not easy to share material; "You can't tell what the other person is thinking". Advantages of co-location naturally complement the disadvantages of videoconferencing, but there are also bonuses: can talk to partner whenever they want; easier to be sure of what the other wants to do; better for sharing information, and comparing notes and ideas.

An evaluation exercise such as ours has such potential complexity that some compromise needs to be made between comprehensive understanding and a simplistic overview. Our particular mix of quantitative and qualitative techniques has helped to tease out some of the many factors involved, and substantial recording of use of the system prepares us to answer further questions relevant, for example, to the development of follow-up systems.

References


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Abstract: The widespread availability of networked communication allows the educational community to provide students with skills needed for pervasive changes in information access and utilization that will occur over coming decades. These skills center on developing techniques for lifelong learning where a broad range of heterogeneous information resources are used in solving problems. The university learning environment we describe provides students with opportunities to acquire skills necessary for success in a distributed workplace where electronic tool use and information discovery, organization, and utilization are the principal activities. The approach we have adopted combines networks, workstations, student laboratories, and multimedia as instructional tools to enhance the students’ learning experience. Structuring student activities through electronic communication creates small-scale electronic communities within which students work and provides a persistent focus on information discovery and integration. Tools that coordinate information access, pedagogy, and problem solving are at the core of students’ learning and working environment. Though some elements of the environment we have implemented are specific to our discipline, most of the elements can be used in any domain.

Introduction

The widespread availability of networked communications, together with the changing nature of the workplace leading into the 21st century, present the educational community with a unique set of challenges and opportunities. The changes created by networked communication necessitates that students acquire skills needed for the pervasive changes that will occur over coming decades. These skills focus on developing both the techniques and an orientation to information that will allow them to engage in lifelong learning utilizing a broad range of heterogeneous information resources in solving problems. Such lifelong learning is not an option or an ideal, but a necessity required by the change in the nature of work and society. The required skills center on preparing students to become members of a learning society [Boshier, 1980] and on becoming an individual operating in an ubiquitous learning environment [Norrie, 1995].

One must be information literate in a learning society. An individual has to be able to know when information is required and have the skills to find, assess, and utilize information when it is needed. Such individuals have learned how to learn because they know how knowledge is organized, how to locate information, and how to make use of information. Those prepared for life-long learning have the skills to find information required for any task or decision. [Green, 1995].

All of the elements to create a learning environment preparing students for the 21st century work environment exist, are widely available, and in some cases inexpensive or even free. Many institutions have made major investments in technology infrastructure. However, a number of factors have prevented a rapid and pervasive shift in the educational model to one more in concert with an information intensive model of the future workplace. Among the factors are the continuous expense of upgrading the technology infrastructure and insufficient user support.

The project described below represents an example of the utilization of network facilities that are currently in wide use to implement some aspects of the move to a new model of education - a focus on information literacy and lifelong learning. Technology is used to enhance both the content of the curriculum and the opportunity for communication with and among students. It serves as a catalyst for teaching and learning. Finally, in our
discipline, computer science, technology assists us in preparing students to be professional computer scientists rather than just computer programmers.

Learning Environment Activities and Design Goals

The university learning environment we have implemented is designed to provide students with the opportunity to acquire the skills necessary for success in a distributed workplace in which electronic tool use and information discovery, organization, and utilization are the principal activities. The environment is designed to foster a general orientation to learning that is self-directed, active, and group-oriented. The activities and types of interaction to be supported in the environment are presented below [Tab.1]. The list also characterizes activities and interactions of present and future information workers, and more generally, the information literate. The elements of the list are drawn from work on the future of the workplace and society [Bates, 1993; Boshier, 1980; Hiltz, 1984], as well as other's experiences in implementing such a learning environment [Andriole, 1995; Debreceny, 1995]. In addition, members of the computing industry, as early adopters of information technologies in the workplace, have provided important insights. Finally, our own experience of several years in using hypermedia in our classes [Fowler, 1993] and the unique needs of our student population have shaped the design goals.

- Work community relationships:
  - emergence of new communities and organizations
  - both distributed and in person communication
  - rapid electronic communication with instructors and group members
  - changing of roles from learner, to mentor, to collaborator

- Electronic tool use:
  - pervasive use of electronic tools
  - integration of tools with diverse functionality

- Information access and utilization:
  - reuse of information through time and across problem domains
  - iterative searching and culling of information
  - facility in manipulating diverse information sources and formats
  - joint use of information

- Efficient use of human resources:
  - recognition of individual learning style and situation
  - multiple mechanisms for learning and working
  - multiple sources and forms of information and work

Table 1. Activities supported to provide a university learning environment preparing students for self-directed learning in a distributed work environment

A University Learning Environment Integrating Networks, Workstations, Student Laboratories, and Multimedia

The approach we have adopted to provide a learning environment preparing students for self-directed learning in a distributed work environment utilizes networks, workstations, student laboratories, and multimedia. The structuring of student activities through laboratories and electronic communication is designed to create small-scale communities within which the students work. These elements are used as part of an introductory computer science course focusing on software engineering techniques for program development, as well as the introduction of a programming language and algorithm development. Given the course content and industry practice, the extensive use of electronic tools for software development is natural, and is a cornerstone of the course. In other content areas analogous tool use is evident. The integration of common software applications packages and multimedia information sources developed specifically for a course with sources available on the Internet is occurring in an expanding range of disciplines. Finding the right mix of these components to design and cost-effectively implement a university learning environment has been the principal challenge of this project.
The approach described here builds on our previous work - a stand alone computer assisted learning (CAL) system using both tools which are modest in cost or free, and tools created specifically to address course requirements. The stand-alone system addresses several, but not all, of the goals outlined in section 2. It provides a sampling of the kinds of information available across networked systems by placing the user in a hypermedia environment containing "semi-structured" course content. The supposition is that the user gains understanding through exploration and the implicit (re)ordering of the information by actively interacting with the hypermedia; the user is actively engaged in constructing knowledge. Given that future networked learning materials are relatively seamlessly linked through the network, this stand alone system is a reasonable, albeit limited, emulation of a networked environment.

Designing and implementing a university learning environment which addresses the complete set of design goals and activities outlined above entails strategies which move beyond the conventional use of multimedia in stand alone CAL. It is necessary to create a distributed work environment which promotes interaction among students. Information sources and tools that support students in the distributed environment we have implemented include web [WWW] and ftp sites with instructional materials, web browsers, news groups, and e-mail. [Fig.1] below shows what a student's screen looks like when working in the distributed environment. Four windows are open on the screen. The upper left window contains the student CASE (computer assisted software engineering) tool displaying a programming team's design for a project. The complete design is visible in the smaller window within the CASE tool window. The Pascal editor running on the student’s workstation is in the lower left window. Information describing a team member's progress, accessed through a local newsgroup, is viewed using a news reader in the upper right window. Hypertext explaining a programming construct is stored at the course’s web site and is viewed through a web browser open in the lower right window. Whether local or networked, text can be transferred between the information access components (web browser and news reader) and the programming tools (student CASE tool and programming environment).

Work community relationships

The primary mechanism for implementing a distributed work environment for students is the structuring of student projects as group efforts with electronic communication as a primary means of interaction among group members outside of scheduled lectures and lab. The learning environment emulates the professional work environment of both today and tomorrow.

The actual structuring of the student projects must be done with care as students are typically in their first or second year, and this is often their first extensive experience with group projects at the university level. Initial group formation and project definition is completed during scheduled laboratories. Groups are systematically formed and reformed several times throughout the semester to represent a range of skills in each group based on student's performance on examinations and previous projects. Efforts are made so that each individual has an opportunity to fulfill both mentor and learner roles within groups.

The laboratory component of the course provides the benefits unique to bringing people together in the same place and at the same time. Whether lab work is completed independently or as a group, the opportunity exists for students to engage in informal discussions with faculty and peers through which they gain new perspectives. Group and project management lab exercises afford students the additional opportunity for systematic face to face or synchronous communication. This communication lets students gain experience in directly coordinating efforts with others whose skills and knowledge sets may differ greatly from their own. The lab interactions provide the foundation for the subsequent communication necessary to complete the group projects.
Local newsgroups are used to foster the emergence of new communities - in this case, communities of computer science learners. At the outset of the course, a single course-wide newsgroup is used for communication concerning work assignments and for student commentary. Students are not only encouraged, but required to contribute to ongoing, unmoderated discussions. There is an element of immediacy, or at least relevance, embedded in the newsgroup and the well known synergy of newsgroups does develop. The more students respond, the more likely it is that a comment will trigger further discussion, thus opening lines of communication and eventually collaboration among students. The archival features of the newsgroup allow the electronic conversations to persist through time, thus supporting the formation of a community by eliminating the temporal constraint of face to face conversation. Ours is a commuter campus and these newsgroups are a significant factor in creating a computer science community.

Additional newsgroups are created and used as the primary means of communication about project work completed after the initial meeting. These newsgroups work well because they support asynchronous work, better suited to temporal availability and work patterns of a commuter campus. Further, the newsgroups serve as a means for instructors to monitor individual student involvement and group progress in a convenient way as compared to group communications conducted exclusively via e-mail.

E-mail is reserved primarily for individual student communication with the instructor, though students can choose to post correspondence to a newsgroup if it is judged useful to a larger audience. The use of e-mail for instructor-student interaction has provided a different structuring of the instructor-student relation. It overcomes some of the practical difficulties of providing rapid feedback on questions. Moreover, students are required to be relatively thoughtful in framing their questions. Student messages tend to be brief, more to the point, and
directed to a single or limited number of topics. In turn, faculty are able to more easily respond to the student at the appropriate skill and knowledge level.

Electronic tool use integrating information access and utilization

The range of tools used in the course integrate information access, pedagogy, and program development. These electronic tools are at the core of the student's learning and working environment and require the student to master several tools using different forms of information: the web browser accessing course hypermedia (problem statements in natural language), the CASE tool (formal program specification), the programming environment (Pascal language), the news groups (group progress and public commentary), and e-mail (personal communication). As with many "paperless courses", assignments and lecture content are available on-line. In our implementation this material is available on the Internet, and students can access it from off-campus. While not encouraged to do so, the student is able to complete most aspects of the course off-campus using the on-line course materials together with newsgroups and e-mail; the exceptions being structured lab experiences and testing.

One of the major emphases of the course is software engineering and much of the student's work centers on the use of the student CASE tool. The CASE tool is integrated with the other components in several ways. For example, program assignments stated as problems are first transferred from either the on-line hypermedia using the web browser or from an ftp site into the CASE tool for further development. The CASE tool supplies a visually-based system supporting problem decomposition following the process of structured program design. Using the editing capabilities and a pseudocode, the student creates a formal specification and design for the assigned problem. From the formal specification, the CASE tool automatically generates the basic Pascal source code, including module calls. The specification and skeletal code generated by the student CASE tool is transferred to the Pascal programming environment for further development. In this process of program creation, the student works with tools which access different forms of information and provide quite different functions in the work process.

It is the interaction among these tools and the transfer and transformation of information among these tools which creates the experience of working in an information intensive environment. Students become familiar with and facile in the transfer and translation of one form of information to another. In addition to information resources provided for the student, the stored problem solutions and code which can be accessed in the hypermedia form a repository which is systematically used throughout the course. The skill and care with which students create these 'information elements' impacts success in projects which reuse information created earlier in the course. In essence, students learn to use tools that facilitate the process of scholarship.

Efficient use of human resources

Time is a scarce resource, whether in the workplace or in the schedules of students and instructors; both our students and our faculty are time poor and commitment rich. Much of the advantage of asynchronous work afforded by network-based projects is realized for student projects and interaction. As mentioned, this style of work and interaction also seems particularly appropriate for institutions which have a large non-resident population. The use of hypermedia materials for course presentation which are also available outside the classroom shares the same advantage. It supplies the learner control and flexibility as to how and when the course material is reviewed. The learner control of content presentation available in hypermedia also accommodates individual's different learning styles and preferences. Nonetheless, the learning environment we have implemented retains a strong laboratory component. We view it as yet another mechanism for learning which should be provided for students in a university setting.

Conclusions

Widely accessible technologies and tools are available to implement a university learning environment which trains students for an information-intensive workplace. Though some elements of the environment we have implemented for our computer science classes are specific to the discipline, most of the elements might be used in any domain. For example, e-mail, publicly available news readers, and web browsers have been successful in creating communities centered in the course. Even where the particular tools used in this project are not appropriate, analogs to those tools which transform and integrate information exist for virtually all disciplines.
It is, however, important to remember that information technology is the medium to enable changes in curriculum, facilitating the development of life-long learners, and not the curricular content itself. Technology is used to support active learning by facilitating work on complex projects, rethinking assumptions, and discussion. In this project we use technology to implement educational strategies which include collaborative, project based learning in an information-rich, tool-rich environment where both synchronous and asynchronous communication occurs to improve student-faculty and student-student interaction, and various styles and preferences of student learning are supported. We believe that these strategies can influence the course of a student’s development and better prepare them for entry into the workplace of tomorrow.

References


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A Framework for CAL Performance Support: An Open Hypertext Model

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Abstract: As Internet and other networked computing environments become more prevalent as primary platforms for learning, effective support tools are required. Learning by exploration and collaboration is not always sufficient, particularly with concept-based material. Computer-assisted learning (CAL) material that relies on a certain level of knowledge and understanding on the part of the user may benefit from performance support. This is seen as especially relevant to subject matter that requires a specific mathematical skill level or the ability to handle abstraction. The performance support framework described in this paper is modelled on open hypertext concepts; it supports the reusability and reconfiguration of existing files of learning materials for inclusion in a performance support module. Although the initial area of implementation concentrates on support for mathematical terms and concepts, the framework can be applied to any discipline for which performance support is warranted.

Motivation for a Performance Support Framework

Using Internet-based material and more traditional CAL for remote learning has the advantage of accessibility, but to date its use has been largely limited to an electronic substitution for course notes and copies of instructors' overhead transparencies. Presentation of content is achieved in some form, but effective learning of abstract concepts is not addressed.

Alternatively, Internet-based material may offer a distributed form of the exploratory learning environment paradigm. The concept of exploratory learning is a more recent approach to computer-aided learning that is supported by open hypertext-type systems. The learning-teaching components developed under Intermedia [Haan et al. 1992], Microcosm [Davis et al. 1992], and Perseus [Marchionini & Crane 1994] are examples of this category of computer-based support for teaching and learning. These systems are characterized by extensive collections of multimedia files pertaining broadly to curricular areas. Related nodes of information within these collections are connected by hypermedia links. Students navigate their way through the information to find material of interest. The hope among enthusiasts of exploratory learning is that the "voyage of discovery" will add value to the learning experience, in that active knowledge seeking is promoted. Although this has yet to be proven, it is a popular form of electronic technology, and certainly provides a rich source of reference material with good information retrieval capabilities. This paradigm is not a replacement for traditional CAL, but rather an alternative for some domains of learning. The exploratory learning model does not implicitly provide any focus of learning for the student; focus must be provided externally by an instructor posing a question or setting an assignment which can be answered by searching the open hypertext system. Also, depending on the searching capabilities of the system and the searching and browsing strategies of the student users, the results of a browsing experience may be unknowingly incomplete.

Regardless of the learning paradigm, the use of CAL material in which prior knowledge is assumed can be less effective than desired if such assumptions are unfounded. The objective of this work is to provide review or clarification of background material related to curricular material currently being studied by way of CAL, hence enhancing the learning process. The concept is not dissimilar to the availability of an on-line thesaurus as it might be applied to looking up the meaning of a word in a passage under study. In other words, it makes the
This paper describes the work in terms of a framework rather than an application for two significant reasons:

(1) Its structure, or underlying design, is important in its own right, apart from the content it conveys. The structure affords the opportunity for new and existing learning materials to be pulled together with minimal effort to provide performance support for any identified topic.

(2) Because its open hypertext flavor dictates that the tool ideally should be available to all CAL presentation environments, its exact implementation will not look the same from environment to environment, although the functionality will be the same. A same-look implementation may be realizable across platforms in the future.

Although the initial motivation for this work was to improve the effectiveness of remote learning, any curricular module (collection of support topics) developed within the framework can also serve as a stand-alone tutorial package. Additionally, an instructor has the flexibility to easily add or change content in order to tailor the material to the needs of a particular class.

The User Interface

The user interface provides the functionality to support the current learning activity. For any reference to a term, technique, or concept which is unfamiliar or poorly understood, the learner-user is able to access a three-phase support facility. We will use the generic word topic to signify term, technique, or concept. The three aspects of support are: passive explanation; visualization; and, an interactive problem set. Any or all of these methods of conveying information may be accessed through straightforward hypermedia links. Since it is often the case that one (remedial) topic builds on a foundation of previous knowledge that may be missing or shaky, a request for support may emanate from another display of support.

Figure 1. The foundation level of support, a static definition.

An open-hypertext-like version of this framework is being developed for Windows-based CAL application environments which allow for add-ins through menu expansion. The resulting add-in menu, Support Topics, allows the user to choose a topic. The response is a simple definition, which may suffice to trigger the needed recall for the user [Fig. 1]. The Expand button included with the definition presents further information on the topic, which may include animation and/or narration. This expansion display is shown in [Fig. 2]. It can be seen that the same Support Topics menu item is available in this window to permit additional performance support to be requested from the current support window. Problem Sets dealing with the topic can be accessed from this display.

The interactive problem set prototype interface can be seen in [Fig. 3]. Within the menu Solution Help there are menu items which guide the process through hint panels (adjunct memory), step-through partial solutions, and suggestions for related support (a controlled-selection dialogue box). There may be many topics for which problem sets are irrelevant. For example, an explanation of photosynthesis or of Kant's categorical imperative may be useful to clarify the material being studied by a learner-user, but working through problems to reinforce the topic may not be appropriate. On the other hand, an abstract topic like mathematical induction may need
reinforcement of hands-on problem-solving in order to be effective. Individual instructor may add problem sets for a topic to strengthen an approach being taken in class.

The problem set display layout has been fixed in order to encourage simplicity of presentation. At the same time the fixed form provides a convenient vehicle for presentation, insofar as each section of a problem set display can accept a predefined node type from the hyperbase of support topic components. This process is described in the following section. A problem may include both a text-based component and a graphical component. The graphical component is optional, but may take the form of a picture, drawing, or animation. An example graphical component might be a .bmp file. Three types of help can be stored to guide the problem-solving process. It may be the case that the learner would benefit from having the procedural steps of proofs available, or a list of Laws of Equivalence for completing a logic proof. Such "hint panels" may be stored and made available to appropriate problem sets. Similarly, step-by-step help may be stored and linked to the appropriate problem. And finally, a list of terms included in the module and specific to the understanding of the current topic may be defined and made accessible.

The Underlying Design
Two important requirements of the framework design were: (1) flexibility of use; and, (2) independence of the content from the presentation method. Flexibility was considered important for several reasons, in order to ensure that: very disparate content material could be equally well accommodated; learning segments could be reused by any appropriate support topic; material could be modified or supplemented by instructor-users; and, associations between related topics could be identified and used to advantage. Independence of content from presentation method was necessary because of the mandate of the project to remain independent, at least in principle, from any particular application development environment. For example, the World-Wide Web is seen as a CAL development environment which can make use of this framework. These requirements were satisfied by defining all topic components as class types and storing all instances, or objects, in a hyperbase. All objects, along with their attributes, associative links to related objects, and in many cases pointers to the corresponding file, are stored as nodes in this hyperbase.

Nodes have several attributes which are used to facilitate configuration of new support segments:

- name/term
- secondary term
- node (object) type (topic, problem set component, explanation, visualization, etc.)
- content, file pointer, or URL
- pointer to list of related terms (for problem set component)
- pointer to list of hint panels (for problem set component)
- pointer to list of solution steps (for problem set component)

Topics are actually composite nodes that consist of a specified collection of atomic nodes such as an explanation, visualization, and problem set.

Instructor-users can add instances of objects or modify the contents of existing ones. This is useful for adding new problems to a problem set or for altering notation to suit that used in a course textbook. Because this repository of support objects is self-contained and separate from the presentation mechanism, alternate approaches to presenting this information to other platforms are feasible. As an example, with some fine-tuning, the open hypertext approach of applications developed under Microcosm [Davis et al. 1992] can access the hyperbase, and subsequently make use of the support material through Microcosm's computed link, or even be incorporated in the Microcosm hyperbase. As mentioned earlier, a World-Wide Web application can be built up from hyperbase entries, which can be stored as URLs. Ideally, a World-Wide Web application could access the hyperbase for adjunct performance support as well.

Several of the design features of this support framework are taken from the open hypertext model, LinkFacility, developed by the author for maintaining end-user authored linking of files and file segments within their own file systems. That LinkFacility model and subsequent implementation, [Fritz & Benest 1994] [Fritz & Benest 1995], provided several features that the author considers to be essential to the usability and relevance of such a support system. In this situation instructors are the user-authors; the capability for instructors to have on-going involvement in updating existing material and adding new material is considered crucial to its success. Following the LinkFacility hyperbase model, the support framework hyperbase provides for:

1. reusability of learning material by defining existing files or file segments as a support node;
2. user authoring of nodes and links; and,
3. the ability of instructors to configure and reconfigure graphically node membership in a support segment.

The Windows-based add-in version of our support framework is created by importing the segments captured in the hyperbase through dynamic data exchange (DDE). A schematic diagram of the overall process of capture, update, creation, and use is shown in [Fig. 4]. The expansion display illustrated in [Fig. 2] has the capability of mapping the contents of a node to an area of the display window that is reserved for that node type. The stored linking information is mapped to the appropriate button in the display window; for example, the problem set button will be linked to the corresponding problem set.
Adding Intelligence

The tool described thus far is seen to have value for performance support. The additional use of the hyperbase for the capture of usage statistics can permit intelligence to be added to the creation process, resulting in increasingly effective content modules. If certain problems in a set have been abandoned frequently, then they may be excluded from the active list. Some information gleaned from a usage log will be acted on automatically; other information will be addressed by the content experts.

Conclusion

The framework described above is currently under prototype development. It is seen as a model for performance support at a much broader level than CAL. We believe that this framework can be used to enhance the effectiveness of many new and existing information technology (IT) applications by providing support materials for all manner of computer-based activities. Currently, computer-based writing activity is supported by the well-proven utilities of spell checkers and thesauri, in the same way that these reference materials have always supported writing activities. In parallel with the tools now available for writing activities, the accessibility of appropriate reference material as provided by our performance support tool can mirror our traditional - and satisfying - habit of pulling a volume off the shelf as we read or study; to jog our memory, to check some background material that has escaped our grasp but is essential to the material under study, or simply to satisfy our curiosity about some tangential thought and make the learning experience more complete. Since the objects in our framework can be entered with a great deal of flexibility as to format, and with minimal effort, the possibilities for expanding the user base are large.

References


Foundations for the Learning Web

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Abstract: The learning web was presented [Norrie and Gaines, 1995] at EdMedia'95 as a systemic approach to the modeling and support of knowledge processes in a learning society. This article addresses the rationale for, and systemic foundations of, the learning web, its implications for restructuring the higher education system, and the role of information technology in supporting that restructuring. Two associated articles report on the implementation of some of the technologies necessary to support the learning web [Gaines and Shaw, 1996], and some preliminary experience in applying them in undergraduate education [Shaw and Gaines, 1996].

1 Reengineering the Educational System

The recession has caused people in general and governments in particular to reassess all aspects of the systems which support our society. We have come to accept basic education and continuing educational opportunities as natural rights that should be universally available without regard to individual financial circumstances. However, the cost of providing these rights has now become a major issue for tax payers and governments. The direction of social change is such that major restrictions on universal access to education will not be acceptable. Hence, the pressure is on the educational system to restructure to be more cost-effective.

Schools and universities have undergone substantial downsizing in the past decade and may have to undergo more. Businesses have gone through similar downsizing during the recession and many of them have gone further than this in examining their fundamental natures and their reasons for existence. Rather than attempt to continue in the same way, using the same processes but with greater efficiency and reduced costs, they have analyzed the customer demand underlying their markets and attempted to reengineer their businesses completely to address that demand using new processes [Hammer and Stanton, 1995].

Like all new approaches to commerce, the business process reengineering movement has had some aspects of a fad, and has been used as an excuse for actions which are independent of, or contrary to, the basic logic of process reengineering. However, there is a compelling logic in the notion that large institutions should periodically reexamine the basis of their existence, and question whether they adequately understand the needs that they were established to satisfy, and whether, if they have that understanding, their processes address those needs in a reasonable way.

A major literature has developed in recent years that critiques universities and concludes that they are failing to fulfill their functions from a wide range of perspectives [Sykes, 1988; Kimball, 1990; Wilshire, 1990; Douglas, 1992]. In general, these studies provide evidence of significant problems but do not offer effective alternatives. Indeed many of them seem primarily concerned with a return to the 'old values', however they are conceived. Those that make a detailed analysis with a view to redesign do so within the existing infrastructure [Wilson and Daviss, 1990; Clotfelter, Ehrenberg, Getz and Siegfried, 1991; Kerr, 1994, 1995] and do not examine the potential for radical change.

There is also a long-standing literature on alternative approaches to the classical university with emphasis on open learning [Thorpe and Grugeon, 1987; Reddy, 1988] through distance education [Daniel, Stroud and Thompson, 1982; Thorpe, 1993] and lifelong learning [Boshier, 1983; Smith, 1983; Husen, 1986]. In general, these studies provide evidence that there are attractive variants to classical university education, and ways to make access more truly universal through a more flexible system. However, they also largely build on the existing system, emulating standard university education as closely as possible, and not questioning whether the conceptual foundations of that education are themselves subject to change.

We suggest it is time to reexamine the social needs that led to the formation of universities and their evolution to their current mandates and modes of operation. Many problems are arising because the universities are still seen as physical rather than virtual institutions [Dolence and Norris, 1995]. Many problems are arising because a labor-intensive approach to teaching that was cost-effective in highly selective institutions has been propagated to universal access. Many problems are arising because content, pedagogy and assessment are all in the hands of individual instructors, and there are no independent standards of effective teaching and learning.
Technology can address some aspects of these problems, and is essential to most potential solutions, but technology alone cannot solve them. We need to reexamine the fundamentals of higher education and be prepared to reengineer the system before technology can be usefully and wisely applied. The learning web concepts are one attempt to do this based on a deep model of the way in which knowledge processes arise in society. We are attempting to apply the concept to learn more about its implementation, and also to use it within existing institutions to explore how much change is possible from within. In the long term, development of the learning web will involve collaboration across many groups world-wide, each of whom has some component of the necessary knowledge support technology.

2 Systemic Aspects of Higher Education

In modeling the knowledge processes in society, we have adopted a collective stance in which the human species is viewed as a single organism recursively partitioned in space and time into sub-organisms, or agents, that are similar to the whole [Gaines, 1994]. These agents include societies, organizations, groups, individuals, roles, and neurological functions. Notions of expertise arise because the organism adapts as a whole through adaptation of its interacting agents. The phenomena of expertise correspond to those leading to distribution of tasks and functional differentiation of the agents. The mechanism is one of positive feedback from agents allocating resources for action to other agents on the basis of those latter agents past performance of similar activities [Gaines, 1988].

Distribution and differentiation follow if performance is rewarded, and low performers of tasks, being excluded by the feedback mechanism from opportunities for performance of those tasks, seek out alternative tasks where there is less competition. The knowledge-level phenomena of expertise, such as meaning and its representation in language and overt knowledge, arise as byproducts of the communication, coordination and modeling processes associated with the basic exchange-theoretic behavioral model. This model has been linked to existing analyses of human action and knowledge in biology, psychology, sociology and philosophy, and used to analyze the role of information technology in supporting activities in the lifeworld.

The collective stance model has implications for the ways in which we conceive teaching and learning. The human species is essentially a learning agent. In relatively static physical and social environments learning will be slow. However, our species has now itself initiated such rapid and ongoing changes in these environments that it must learn to cope with them at an ever-increasing rate. As Wojciechowski [1983] has noted, the growth of knowledge can itself be regarded as the major source of the problems that demand the generation of further knowledge. This positive feedback loop now drives our existence as a species.

The model provides some interesting insights into the differentiation of activities into 'teaching' and 'research.' All individuals may be seen as acquiring expertise through 'research,' and as having social pressures to disseminate that expertise through 'teaching.' The dissemination of expertise through teaching is an essential complement to its formation through learning as a social process for creating continuing and large-scale resources from short-lived and limited-capacity individual agents. There is no social value in the expertise of a particular individual unless that expertise is propagated in some way. This suggests that we characterize a researcher by the community that he or she teaches, that is to whom the researcher delivers knowledge. If that community is small then the research is specialist. Natural divisions into communities of mutually teaching individuals correspond to knowledge disciplines and sub-disciplines. The disciplinary structure of academia is functionally determined by the teaching relationship within this broad interpretation.

The emphasis of the collective stance model on the positive feedback processes generated by reward structures throws light upon the problems that universities currently have in attempting to promote teaching as a professional responsibility of at least equal stature to research. The inception of refereed journals some 300 years ago provided a mechanism for both disseminating knowledge and evaluating the products of research that leads to a system promoting excellence in research. The North American higher education system has no similar mechanism for promoting excellence in teaching. On the contrary, most institutions have minimal constraints upon the content of a particular course so that the instructor defines the content, teaches it, and examines it. There is no mechanism for external evaluation and hence no possibility for feedback processes promoting excellence. Control is exerted at the wrong level by requiring each course to conform to approximately the same distribution of grades. The meaningless nature of the processes involved can be seen by noting that, under the current system, an instructor whose students all attain 'A' grades will be criticized, whereas the same instructor under a system where the students were assessed independently to national standards would be rated an excellent teacher. The current system also is negative to collaboration between students since it is not in one's interest to improve another students chances of getting an 'A' if it reduces one's own.

Thus, the collective stance model has many implications for teaching and learning that are independent of issues of
technological support. There is no 'right' way of restructuring the system, but any way that neglects the essential processes involved is unlikely to succeed no matter how much technological support is provided. The learning web approach above all else emphasizes the dynamics of human knowledge processes, and the introduction of support technology needs to be based on a deep understanding of those processes.

3 The Learning Curves of Technological Convergence

For those who have been involved in educational technologies and the roles of computers in education and society throughout their lifetimes and have seen many false dawns and promises, an obvious question must be 'why now?'--why should we expect to be able to use information technology to facilitate radical change in the educational system when we were not able to do so in the 60's, 70's and 80's? Information technology itself arises out of social processes and can be modeled through the 'learning curves' involved in those processes [Gaines and Shaw, 1986]. Beninger [1986] provides a socially-grounded rationale for computing and information technology as yet another step in the "control revolution" commencing in the 1800s as a response to the increase in the speed, volume and complexity of industrial processes:

"The Information Society has not resulted from recent changes but rather from increases in the speed of material processing and of flows through the material economy that began more than a century ago. Similarly, microprocessing and computing technology, contrary to currently fashionable opinion, do not represent a new force unleashed on an unprepared society but merely the most recent installment in the continuing development of the Control Revolution." (Beninger 1986)

This analysis provides an adequate systemic and historical account for the majority of the significant phenomena associated with the "information age." It is a significant, but not isolated or revolutionary, stage in an ongoing process of industrialization which is itself grounded in the social needs generated by human population growth beyond a level sustainable without technological support. What came first, the population growth or the technological support for it, is too simplistic a question to have a meaningful answer--one is dealing with a system having strong positive feedback loops that seem themselves adequate to account for much of the perceived autonomy of living systems [Ulanowicz, 1991]. Toulmin's [1990] thoughtful and provocative account in Cosmopolis of the modern era as a response to a sixteenth century social crisis is in itself sufficient to undermine any concept of autonomous origins for the seventeenth century enlightenment that resulted in science, industry and the information age.

There is a simple phenomenological model of developments in science technology as a logistic "learning curve" of knowledge acquisition [Marchetti, 1980]. The logistic curve has been found to be a useful model of the introduction of new knowledge, technology or product in which growth takes off slowly, begins to climb rapidly and then slows down as whatever was introduced has been assimilated. Such curves arise in many different disciplines such as education, ecology, economics, marketing and technological forecasting [Dujin, 1983; Stoneman, 1983]. One problem with using them predictively is that the asymptotic final level can only be estimated in retrospect, and attempting to determine the form of a logistic curve from data on the early parts is notoriously sensitive to error [Ascher, 1978]. However, fitting logistic curves to historic data gives a very precise account of the development of major technologies such as the successive substitutions of one form of energy production for another [Marchetti and Nakicenovic, 1979].

It has also been noted in many disciplines that the qualitative phenomena during the growth of the logistic curve vary from stage to stage [Crane, 1972; De Mey, 1982; Gaines and Shaw, 1986]. The era before the learning curve takes off, when too little is known for planned progress, is that of the inventor having very little chance of success but continuing a search based on intuition and faith. Sooner or later some inventor makes a breakthrough and very rapidly his or her work is replicated at research institutions world-wide. The experience gained in this way leads to empirical design rules with very little foundation except previous successes and failures. However, as enough empirical experience is gained it becomes possible to inductively model the basis of success and failure and develop theories. This transition from empiricism to theory corresponds to the maximum slope of the logistic learning curve. The theoretical models make it possible to automate the scientific data gathering and analysis and associated manufacturing processes. One automaton has been put in place effort can focus on cost reduction and quality improvements in what has become a mature technology.

Figure 1 shows this BRETAM sequence plotted along the underlying logistic learning curve. In most industries the learning curve takes some tens of years and the major effects are substitution ones. Substitution occurs when an old technology has reached maturity and a new, more effective technology, reaches a point on its learning curve where it economically replaces the old one. There is also a secondary phenomenon that when a technology reaches a point on the learning curve where it is cost-effective and reliable new technologies develop dependent on the first one. For example,
the electric lighting and appliance industries developed as the power generation industry came to offer cost-effective and reliable electricity supply.

The dependent technologies themselves develop along their own learning curves and may come to support their own dependents. Figure 1 shows a tiered succession of learning curves for dependent technologies in which a breakthrough in one technology is triggered by a supporting technology as it moves from its research to its empirical stage. Also shown are trajectories for invention, research, product innovation, long-life product lines, low-cost products and throw-away products. One phenomenon not shown on this diagram is that the new industries can sometimes themselves be supportive of further development in the industries on which they depend. Thus, in the later stages of the development of an industrial sector there will be a tiered structure of interdependent industries at different stages along their learning curves.

This model of the tiered infrastructure of information technology was used at the first ICAL in 1987 to provide an account of changing patterns of innovation in educational technology over the years [Gaines, 1987]. Two things have changed since then. First, we have another 8 years of data which has confirmed the predictive power of the model—information technology has continued to develop along the trajectories predicted without significant deviation. Second, the emphasis 8 years ago on the increasing role of machine intelligence was misguided—research into artificial intelligence and expert systems has failed to fulfill its aspirations and promises. What has happened instead is that computer-mediated communication has been very effective in empowering human intelligence. News groups, list servers and the World Wide Web enable us all to tap into human expertise on a scale never previously possible. A quote from the early seventies before any of these technologies existed captures the essence of the matter:

"No company offering time-shared computer services has yet taken advantage of the communion possible between all users of the machine...If fifty percent of the world's population are connected through terminals, then questions from one location may be answered not by access to an internal data-base but by routing them to users elsewhere—who better to answer a question on abstruse Chinese history than an abstruse Chinese historian." [Gaines, 1971]

News groups and list servers now operate in precisely the manner suggested, with questions being posed and answers being given by experts in the relevant domain, a learning web in action.

Technically, the critical trajectory for computer-mediated communication in Figure 1 is that in the 7th generation
commencing in 1996 interaction technologies become mature and cross the divide between low-cost generally affordable products to the virtually throw-away products that are affordable throughout the educational system. It is the maturity of electronic technology, digital architectures, software technology and interaction technology combined that is leading to the digitization of telecommunication technologies and their convergence with computer technologies [Negroponte, 1995]. This is leading to convergence of the cable television, telephone, computer and media industries towards an 'information highway' [Trainor, 1994; Maney, 1995], and it is this consumer application of digital telecommunications and computer technologies that is creating a mass market for low cost products that can be used for computer-mediated communications in education.

4 Conclusions

This article has addressed the rationale for, and systemic foundations of, the learning web, its implications for restructuring the higher education system, and the role of information technology in supporting that restructuring. It models knowledge processes in human societies from a collective stance which views the human species as a single organism recursively partitioned in space and time into agents that are similar to the whole. It models the formation of expertise in society as a positive feedback process in which agents allocate resources for action to other agents on the basis of those latter agents past performance leading to functional differentiation of individual learning agents. It models various aspects of education as a means of disseminating expertise to create continuing and large-scale resources from short-lived and limited-capacity individual agents. The role of information technology is modeled as one of providing knowledge support systems that expedite the processes of knowledge formation and dissemination. The learning curves of information technology are themselves modeled to provide insights into the present convergence of telecommunication and computer technologies to provide the so-called 'information highway' that makes it possible to implement the learning web on a large scale.

The technological infrastructure to support the learning web is becoming available now and will be widely available by the year 2,000. However, the educational infrastructure to use it effectively is not yet in place. Universities have to reengineer their processes to take advantage of the new technologies and develop new roles as service providers on the information highway. To do so they need a much deeper understanding of their existing roles in society. The learning web concepts are one attempt to provide a basis for such understanding.

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References


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Abstract: The paper describes the computer-aided knowledge engineering technology (CAKE) which is intended to support knowledge engineer at the stage of prior conceptual structuring of the knowledge domain. The visual two-dimensional knowledge representation language is introduced, with which the hierarchical conceptual structure, the dynamic relational functional structure and the hypertext structure of the domain are described. The relation of this language to the traditional AI languages is presented. The concept of heterogeneous knowledge source is then introduced to show wider applicability of the described technology to extracting of domain knowledge structure from the sources of various nature, in particular, in the framework of modern distributed textual databases.

Introduction

For many years the knowledge acquisition was an exclusive domain of a particular class of professionals – so called «knowledge engineers». These people were usually thoroughly tutored and trained in their field, and their personal experience and high qualification made their work quite expensive. The tools for automatic knowledge acquisition, developed in parallel, certainly couldn't replace completely a human sight on the things. Usually, each time the new (fuzzy) knowledge incomes, an experienced knowledge engineer should structure it to make possible its further automatic processing.

The new state of computer technology enables one to change this situation.

First, the modern generation of the software construction tools for the user-friendly graphic interfaces and increased overall system support for a non-programmer computer user make it possible to facilitate the work of a knowledge engineer analogously to what is made in the field of CASE's. One might talk in this way about CAKE technology – i.e. Computer Aided Knowledge Engineering, aimed to help the knowledge engineer to perform the prior stage of conceptual structuring of the knowledge domain. The use of visual images, icons, pictograms and an ability to impose a structure on them (similar to a pictorial, two-dimensional view of a semantic network) might be of substantial value in this way, eliminating the necessity to use a formal artificial intelligence (AI) language to tediously describe (usually obscure) relations between the concepts of the subject domain.

Second, the information explosion, the wide availability of remote textual and hypermedia databases, more facilitated personal communication makes it reasonable to talk about a special computer-aided support for everybody who deals with structuring (or simply apprehension) of large volumes of information. This people might be called «knowledge workers». They are: scientists, journalists, lawyers, managers, businessmen etc. In this way, a CAKE system might combine a bibliographic (hypertext) database with more or less complicated knowledge structuring features.

This paper describes one of the first stages of the development of such a technology. The system prototype (called KEW – the Knowledge Engineer's Workbench), implementing its principles, includes: visual static conceptual structuring of the subject domain, visual representation of a dynamic relation structure of the domain, and an hypertext structure, which application is two-fold – both as a detailed description of an element of the static conceptual structure and as an intermediate node between the target structure and the original knowledge source. These structures together may be called as «domain model». 
Visual Knowledge Structuring within the CAKE Technology

Knowledge Acquisition Tools

Acquiring and modeling knowledge effectively can be the most time-consuming portion of the knowledge engineering process. Knowledge acquisition (KA) is not just a single idea, it is closely related to research in more general knowledge system issues, and it covers a wide range of technologies. The last 5-7 years the main interest of the researchers in this field is concerned with the special tools that help knowledge capture and structuring [Boose 1990], [Eisenstadt et al. 1990], [Gaines 1989], [Gavrilova et al. 1992]. Many KA tools and methodologies assist to cut down the revise and review cycle time and to refine, structure and test human knowledge and expertise [Wielinga, Shreiber & Breuker 1992].

The short prehistory of knowledge engineering (KE) techniques and tools (including knowledge acquisition, conceptual structuring and representation models), the overall overview of which is presented in [Boose 1990], [Tuthill 1994], is an ascending way to develop the methodology that can bridge a gap between the remarkable capacity of human brain as a knowledge store and the efforts of knowledge engineers to materialize this compiled experience of specialists in their domain of skill.

Beginning from the first steps and research that show the "bottleneck" in expert system development up to nowadays the AI investigators and designers has been slightly guided by cognitive science. So major part of KE methodology suffer of fragmentation, incoherence and shallowness.

The highlights in this area relate to early works in 80-ies and next impact to knowledge acquisition refinement which is concerned with the visual knowledge engineering [Aussenac-Gilles 1993], [Eisenstadt et al. 1990] that develop novel technique aimed at knowledge engineers. Such approach helps to traverse and organize visually an emerging knowledge store in rather natural form, for example as an «image panel» or a sketchpad for the visualization maps, diagrams and pictures. Although the popular methods described above are genuinely powerful and versatile, the knowledge engineer is weakly supported at the most important and critical stage in the knowledge engineering life cycle - transition from elicitation to conceptualization by understanding and realization of the domain structure and expert's reasoning way.

Knowledge Structures Mapping by KEW

The process of the prior knowledge acquisition includes the identification of the key notions (concepts) of the given domain and a set of links between them - both static (such as «ISA», «HAS_PART») and dynamic (such as «event X may cause event Y»). This process may be iterative, reflecting the gradual apprehension of the domain structure.

The KEW system proposes to its user the tool based on classical structured analysis methodology [Yourdon 1990] enriched by new results that gives knowledge engineer the opportunity to use special graphical interface to create the structure, to save it and to compile into the knowledge base. The approach can be determined as building of second generation KE/KA tools, which are enriched by visual capacities.

The underlined importance of the interface-centered technology puts emphasis on the user's comfort, handiness and simplicity. The described KEW system illustrates the idea of knowledge mappability, that find another application in the data mining and structuring for heterogeneous data base design.

A computer program, which could be really useful for a knowledge engineer on the prior stage of the structuring of the given domain, should necessarily follow the phenomenological nature of the knowledge elicitation. This program must not frustrate the knowledge engineer with any «game rules» which were not evident for him/her. Ideally, it should adjust itself for particular cognitive features of the knowledge engineer. Only in this case it could really meet the real-time structuring (e.g. a «brain storm») without slowing down the «on-the-fly» structure editing.

In this way, the system KEW proposes a kind of a visual knowledge representation language, which analogs may be found in a wide range of visual software construction tools – from large CASE's to Visual Basic. In particular, it supports the principle of a bi-directional mutually unambiguous correspondence between the two-dimensional visual object description syntax with the traditional one-dimensional one.
The main window of the system is divided into three parts.

The conceptual structure editor (the upper left pane) enables one to either create the new concepts from the scratch or to drag-and-drop them from the hypertext «pool» (the upper right pane), representing the original knowledge source. Some of these concepts (regarded as «terminal») may have a set of «values» of very abstract nature. These values (or some ranges of them) are listed below the concepts. The static links (or «arcs» in the terminology of semantic networks) are drawn using either the drag-and-drop interface or through a menu-driven command box. In the described version of the system only a pre-defined set of link types is implemented (ISA, HAS_PART, HAS_PROPERTY, IF, FUNCTIONS_AS). An ability to draw arcs with arbitrary names – as usual for semantic networks – was discarded experimentally, because it takes a larger number of primitive interface actions than to simply create an intermediate concept and connect it with its counterparts. Certainly, this influences the «logical» model of the domain structure as we shall see below. All the manipulation primitives of this part of the system are similar to modern picture editors, except that KEW knows more about the «nature» of it's graphic objects.

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The main role of the hypertext structure (the upper right pane) is to keep some textual description of the corresponding node of the conceptual structure (similar to «memo» fields in databases). The links from such memo fields can be drawn directly to some other nodes of the conceptual structure. Thus the visualization of the hypertext structure is achieved as a byproduct of the visual concept structuring.

The lower part of the window represents the functional structure, which uses the tabular, QBE-like form to describe the dynamic, logical relations between the concepts. Each table of this kind may be regarded as a «predicate» under the possible values of terminal concepts. More precisely, each row of such a table is a logical database, containing only monadic predicates (see below).

Such a «predicate» should be distinguished from a set of «productions» of any kind. The aim of functional structure is quite different. It is rather declarative than «pragmatic» and serves for the development, investigation and «debugging» of the domain model.

Logical Description of the Domain Model

The two-dimensional «language» of the KEW visual structure editor can be mapped onto a traditional one-dimensional formal description language in many various ways. Theoretically speaking, a domain model, which is built by KEW, can be described by a monadic first order logical theory. Practically, in the current implementation of KEW an extension of Prolog language is used. The ideas of this extension (called Netlog) are described in [Voinov 1992]. Using this language, one can map each concept onto a named logical database (called a «module» in Netlog), where the HAS_PART and HAS_PROPERTY links to the terminal concepts are represented as (local) predicates, while those links to non-terminal concepts are represented by sub-databases. The ISA link is represented as a reference to the corresponding parent. For example, a structure of the form
An analogous mapping is built both for the functional structure of the domain model and for the queries. Their detailed description is out of the scope of the topic of the current report.

KEW for Hypertext Design and Browsing Support

Visual Design of Complex Structures from Heterogeneous Sources

The term Heterogeneous Knowledge Sources is supposed to include:
1. Expert interviews.
2. Lecture conspectus.
3. Private communications (as usual while on a conference).
4. Audio speech records.
5. Remote textual database queries.
6. Traditional textual information (books, articles, newspapers, etc.) either in a hard-copy, or in an electronic form.

A better apprehension of each of such streams of data might be achieved by imposing on them a knowledge structure. This may improve later usage of this information, comparing, generalization, and so on. Therefore, a visual knowledge structure editor plays here a role of a two-dimensional, pictorial conspectus of the regarded piece of information.

With KEW, this process may conclude in the following steps:
* Prepare the original bulk of (hyper)text containing the material (and import it into the hypertext pane of KEW).
Borrow the key notions of this material into the concept structure pane and impose a set of links. Perform generation of other concept structure if needed.

Distribute the remaining text throughout the «memo» fields, attached to the corresponding key notions. These memo fields serve as «comments», intended to keep remaining not formalized information together with their nodes.

Draw hyperlinks from these «memo» fields directly to the relevant concepts in the concept structure pane. This will enable the proper hypertext navigation, semantically corresponding to the revealed knowledge structure.

If needed, export a hypertext document in a traditional form (including an html-file).

The use of functional structure in this case is related to more complicated knowledge-hypertext structures, which might include variable templates and provide a possibility to become «instantiated» with more specific information, which may be regarded as a different aspect of the considered hypertext database. For example, there might be a large hypertext database about a city, where each element of the city may be described from many different aspects. Each «query» to such a database may be professionally specific, when some people is interested in some properties of the objects. For example, the information about the petroleum stations and tobacco factories may interest the fiscal inspection, the fire-fighting service and the medical services in very different ways. Therefore, the hypertext documents, resulting from their queries, would possess very different semantic structure. This may be achieved by «weighting» different components of the query and thus highlighting or hiding the corresponding nodes of the knowledge structure. As a result, the less «probable» hyperlinks (such as – some hypothetical – petroleum-station-revenue-rate for a fire-fighting service) will be hidden and the corresponding information will not occur in the resulting document.

Hypertext Tutorials and Databases: Active Browsing

Many modern Internet hypertext tools, such as Mosaic and Netscape, are intended to serve as graphical browsers for a global hyperlinked mediaspace. Really, however, every user of more or less complex hypertext structure is usually frustrated by a chaotic labyrinth of crosslinks. This is especially valid for the WorldWideWeb as a distributed hypermedia system, where the sort of the associated information is usually unavailable for the local node.

The imposing of the knowledge structure on such amorphic hyperlink spaces can dramatically shorten the conceptual apprehension of the corresponding flow of information. In this way, the CAKE technology, even in the described implementation, appears to be useful in this scope of problems, because it offers key functionality for elucidating of the basic logical skeleton of the domain. Even the plain visualizing of the logical schemata of the domain have the powerful cognitive impact both to the user and to the designer.

The application of the CAKE technology could change the entire design cycle of the hypertext tutorials and database development. It forces the designer to follow the top-down technology versus the bottom-up one.

The least but not the last contribution of the CAKE technology into this scope of problems concludes in the possibility for the end user to consciously navigate through the hypermedia space, while gradually increasing the knowledge structure of the path left behind. Such structure may generalize the primitive apparatus of bookmarks and index files.

The active browsing support currently implemented in KEW allows the user of the system to automate both the analysis and synthesis procedures of these activities.

Conclusion

The proof of a framework’s value is how much time and cost one saves when developing and modifying the knowledge base and hypertext environment. The framework of KEW is a modern design environment with the openness, and tool and data integration capabilities one needs to:

- Provides an easy-to-use strategy of visual knowledge acquisition from heterogeneous sources of expertise.
- Significantly lower the cognitive efforts of both the designer and the user of a knowledge/data based system.
* Increase the designer’s productivity through the visual browsing support.
* Create an environment that optimizes the way of developing of both knowledge based and hypertext products.

The bottom line is that the described approach helps to navigate both in the materialized logically linked spaces and the imaginary ones, which were usual for the traditional forms of the expertise transfer.

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Interactive Multimedia Information: Evaluation by home users

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Abstract: In an attempt to provide a set of criteria to evaluate home multimedia products established methods in the fields of human-computer interaction (HCI), computer-assisted learning (CAL) and information retrieval have been considered. Given that the needs and motivation of home users are likely to be distinct from those of business or education users these established methods can only be a starting point. It is suggested that factors such as aesthetics, levels of interactivity and information content may be crucially important in user satisfaction. Field investigations are reported looking in-depth at the ways home users interact with multimedia encyclopaedia CD-ROMs and how they rate the importance of different evaluation criteria. A great diversity of motivations for acquisition of the products, usage patterns and perceived importance of evaluation criteria is found. It is suggested that in-depth study amongst identified categories of users is needed to further identify valid evaluation criteria.

Introduction

With a huge and rapidly growing range of CD-ROM titles available, how is the home user to determine which suits their needs or desires? People are used to handling paper information sources in the form of books and magazines. They may use a set of semi-conscious heuristics when evaluating a book prior to purchase. The consumer CD-ROM is a new medium. Its contents are less familiar. The physical appearance of a disc gives no clues as to its information and media make-up. While the contents of a CD-ROM may share common characteristics with books, access to the information is quite different. They also contain media other than text and static illustrations, integrated in ways which are new to most consumers.

Evaluation criteria are needed to assist potential users and their advisors (e.g. library staff, publishers, magazine reviewers) in choosing from a huge range of products. The evaluation described here takes a holistic user centred view, rather than being aimed at developers. The criteria may also be relevant to the providers, present or future, of multimedia information for home users over networks.

As part of a pilot study investigating the information seeking behaviour in a small number (20) of households in central Scotland [Davenport et al. 1996] a potential set of evaluation criteria have been developed [Gillham et al. 1995]. In-depth interviews were carried out in May and June 1995, on a self-selected sample of households, all of whom had in their homes a multimedia capable computer. This evaluation involved naturalistic observation, defined by [Egan 1990] (p. 387) as a type of study which ‘...asks whether the system really meets a critical need, whether people choose to use or avoid the system, and how the embedded system affects users' efficiency, productivity, and satisfaction’. While the above study aimed to set the context of home use, the study reported here looks in detail at the use of home information products (multimedia CD-ROMs) by people in their homes.
It investigates how users interact with the systems and gathers data on what they consider to be relevant evaluation criteria.

This paper is concerned with what might be called the mass market of multimedia information products which are primarily aimed at the home consumer. These CD-ROMs differ from the long established academic and business information sources in their purpose, target audience, content media and access methods. Home titles are usually described as interactive and multimedia information systems. A home multimedia product will have textual information plus realistic photographic images, high quality sound and often animation and/or video. The term interactive implies an exciting involvement in the way the information is presented and retrieved. Features allowing interaction include hypertext access to the information, a variety of searching and browsing facilities, backtracking, bookmarks, user tailoring, facilities to make your own links, lists and presentations. The minimum expected would be for products to allow the user to control access in more than one way, including non-linear navigation of the information using hypertext facilities.

Characteristics of the Home User

The way in which computers are used in the work setting contrasts with the home situation in terms of time, motivation and social context [Whiteside et al. 1988]. There is no such thing as a single type of user. Just as the type of work place user varies ([Garcia 1988] pp. 38-39) describes ‘the political user’, ‘the asking user’, ‘the managing user’ and ‘operating user’) similarly there is no single type of home user. Educational background, ability and experience of computers will vary in such an uncontrolled environment. The user may be a homeworker (adult or child), a student, a technical enthusiast, an interested browser etc. People’s reasons for using computers at home differ; indeed, the same person’s reasons for use will vary over time. The purpose of specific CD-ROM products is not always clear. They are often promoted as satisfying an educational and entertainment role.

Factors influencing basic usability are likely to be the same for home users as work users. All users will want clear instructions, concrete icons, lack of errors and positive feedback. [Marchionini 1992] stresses that the user wants to achieve their goals with the minimum of cognitive load and the maximum of enjoyment and that we all seek a path of least cognitive resistance and prefer recognition tasks to recall tasks. It is likely however, that the motivation and reasons for use of systems by the home user mean that established areas of perceived good design are not always true, and a shift in relative importance of different factors may occur.

Evaluation Methods

Our research is concerned with how a finished product may be usefully evaluated, that is with summative evaluation. Summative evaluation is in itself not new [Knussen 1991], but little summative evaluation has been aimed at studying the home user interacting with the current generation of CD-ROM based products. How should one conduct summative evaluation of multimedia products for the home? An obvious answer to this question is to simply transfer methods previously successfully applied to other areas, such as CAL, HCI or information retrieval.

Techniques used include user observation, verbal protocols, software logging, surveys of users' opinions using interview and questionnaire techniques, and heuristics [Knussen 1991, Preece et al. 1994, Nielsen 1990, Dix et al. 1993] which in many cases are themselves variants on a range of social research methods. The relevance of work in the fields of HCI, CAL, information retrieval and the evaluation of hypertext to our project has been discussed by [Gillham et al. 1995].

While design centred evaluation can be carried out at all stages of a development, we are concerned with summative evaluation of the final product. Summative evaluation tests a product against normal practice [Laurillard 1994]. Normal practice for a home user searching for some information will usually be to consult a non-computer source, often a book. It may be however that if the CD-ROM was not available the information would not be pursued. In this case, and when the activity is obviously recreational, the ‘normal practice’ is
doing something else with one’s time. The home product is likely to be in direct competition with other recreational activities. It may be that the closest alternative is often the book. However, it can be argued that a major competitor for time is the television, and that the multimedia CD-ROM can compete favourably with television by offering the user superior control over information flow [Davis 1993].

Most established evaluation methods are based on systems designed for work place use or in controlled education and training environments. They do not clearly identify the key areas of importance to users of home products. There are a number of characteristics which are arguably unique, or at least highly specific to the home user situation, and this should be reflected in the evaluation criteria which are applied. There follows a discussion of the factors that may be considered in establishing the long term value of home multimedia products.

Evaluation Factors of Relevance to the Home User

A first step to providing practical help with CD-ROM evaluation for the home user and their advisors is to examine the components of these products. Given the variation in user characteristics and lack of knowledge of user needs and desires, we need to initially take a broad view and analyse the different components of a typical home CD-ROM information product. Dimensions for analysing an application can be identified, such as content, structure, presentation, dynamics and interactions [Garzotto et al. 1995]. Unlike the work place computer system, the home CD-ROM is a consumer product that is usually bought, installed and operated by an individual (or family group). We need to look at the whole experience with the product that a user will encounter, once it is acquired.

Previous work by the authors [Gillham et al. 1995] gives a long list of factors of potential relevance to user satisfaction under headings such as support, information content, navigation, the visual interface, multimedia elements, interactivity, aesthetics and creativity, and performance and reliability. It is suggested that a small number of key factor may have a major impact on user perceptions about system quality. Compared to workplace users it is likely that domestic users will have a higher demand for products to be aesthetically pleasing with engaging interactivity. The importance with which users rate the following criteria in particular are tested:

- does it meet or exceed expectations?
- is the content suitable in depth and breadth?
- is navigating satisfying?
- are the multimedia elements of satisfactory quality, quantity and appropriateness?
- is there a satisfying level of interactivity?
- is the system enjoyable to use and aesthetically pleasing?
- does the system perform adequately?

There is likely to be a shift in usage patterns and user demands over time. Initial access to the systems tends to concentrate on novelty of the dynamic media, the video, animation and sounds. In this research any early indications of shifts in relevance of the evaluation criteria are recorded.

Methods

The Case Study approach

A multiple case study approach is being used with households identified within central Scotland which have a multimedia capable computer. Our justification for using the case study approach in this research programme is based on work described by [Benbasat 1987] indicating the value of this type of research strategy in information systems research. In this instance 13 individual case studies (the multiple case study approach [Benbasat 1987, Yin 1994]) are undertaken in order to attempt to replicate the results. The use of multiple cases may allow
patterns of usage to be observed which may add weight to any observations about the needs of home users. Sampling is not a major aspect of the case studies as each case is seen to be unique and of value in its own right. All subjects had owned a multimedia capable computer for at least 12 months and were using one of the following multimedia encyclopaedias: Encarta (94, 95 and 96)Grolier’s, Compton’s.

The Research Questions

Following the recognised case study approach of identifying research questions [Stake 1995] and based on previous case studies carried out by the authors to ascertain what and how multimedia products are used in the home, the following questions were formulated:-

• can home multimedia systems be successfully evaluated according to predetermined key criteria?
• what is the relative importance of each of the key criteria?
• are there any changes in the pattern of usage of home multimedia system as the user becomes more experienced with the products?
• does user experience influence the perceived importance of any of the key criteria?

Evidence has been collected using a variety of methods thus allowing triangulation of the results.

Data Collection

An initial pilot investigation to test the research process enabled fine tuning resulting in the development of the following methodology for data collection. Firstly, the subjects were asked to use their own multimedia encyclopaedia in a way which they would normally do so. Notes were taken by the interviewer. Secondly, the users were interviewed using the quasi-formal questioning style reported by [Henderson, 1995]. Questions of a mainly open ended form were asked about their use, knowledge and views of general and specific aspects of the product. Thirdly, an experimental approach was adopted where the subject was asked to locate information on specified topics within the encyclopaedia and to find the answer to specific questions. Notes on the approaches used were taken by the interviewer. Finally, the user was asked to rank particular aspects of the multimedia system.

Results & Discussion

Most of the general questions relating to satisfaction produced a high level of agreement from the subjects. They are surprisingly uncritical and enthusiastic about the products and their constituent parts. The overwhelming majority of subjects stated that:-

• the systems exceeded their expectations
• navigation was easy and satisfying
• multimedia elements were of a satisfactory quality, quantity and appropriateness (a few reservations on quantity of videos and animations)
• there was an adequate level of interactivity
• the system was enjoyable to use and aesthetically pleasing
• system performance was adequate.

Most users were happy with the balance of content between depth and breadth, but a few were disappointed with a lack of depth in some areas. The only common complaint concerned the emphasis in material about North America at the expense of more local detail (only one user had a European English product).

A lot of information was collected on the behaviour of the subject while accessing the systems. This will be more fully presented elsewhere but the subject's initial access strategy can be broadly classified as:-
key word searching of the article lists
information filtering by subject hierarchies
filtering by particular media types and playing or viewing selected clips.

The more focused users who were looking for information on a specific topic, often children doing homework, tended to access articles by typing a keyword, while others would browse through subject hierarchies and lists of media examples. Several subjects freely combined these access methods and a few made use of hypertext links and guided tours.

None of the subjects were new users, all having owned the information product for at least a year. Answers to questions of their understanding of technical information retrieval terms allow a crude division of the subjects into the more or less technically experienced. The more experienced users tended to be those who were computer literate before acquisition of a computer for their home. The less experienced users tended to be less efficient searchers often using subject trees to find an article when a simple word search would have been much quicker. Some were very loath to give up using the mouse for a few moments in favour of typing; one commented that using the keyboard would mean not looking at the screen while with mouse control they could still watch the screen. Subjects were asked what they would 'do' if they did not have the encyclopaedia CD-ROM. Several of the less experienced users stated that they would indulge in some other activity, such as watching television or reading a book. The questioners were expecting a comment on what alternative source of information they might consult. Many, but by no means all, of experienced users did suggest an alternative information source. This suggests a fundamentally different approach to use of the product with some people seeing it as an alternative leisure pursuit and others as an information source.

While most subjects were positive about all criteria investigated, the ranking of some potentially key criteria allows us to get a picture of the relative importance of the factors. Seven criteria were ranked by the subject and given a score of 1 - most important to 7 - least important. From the 13 subjects, average scores have been calculated suggesting that searching is most important criteria, followed by the textual content (Fig. 1).

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Searching</td>
<td>2.21</td>
<td>1.61</td>
</tr>
<tr>
<td>Textual content</td>
<td>3.23</td>
<td>1.69</td>
</tr>
<tr>
<td>Browsing</td>
<td>4.27</td>
<td>1.88</td>
</tr>
<tr>
<td>Multimedia</td>
<td>4.31</td>
<td>1.80</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>4.31</td>
<td>2.06</td>
</tr>
<tr>
<td>Interactivity</td>
<td>4.85</td>
<td>2.19</td>
</tr>
<tr>
<td>System Performance</td>
<td>4.92</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Figure 1: Evaluation criteria ranking statistics (n=13).

Interactivity and system performance are ranked least important factors. It is interesting to note that aesthetics and interactivity are not rated particularly highly overall although these factors do have the largest variance. It may be that subjects perceive these factors as less worthy than features such as searching and textual content and their answers reflect this. It may also be that the users do not fully understand the meaning of these terms. Interactive multimedia has become a popular term in the media, but do the consumers of such products actually understand such terminology?

Usage technique and stated importance of the evaluation criteria do to some degree reflect the purpose for which the product was bought. One subject, a mature student with a background in the media, bought the encyclopaedia because he is interested in multimedia. His use consisted mainly of access via the guided tours, dipping into subjects in a peripheral way, accessing the media clips. He ranked the factors of multimedia and interactivity first and second respectively. This contrasts to another subject, a farmer with two school age children. His purpose for getting the product was to help the children with school work saving a 15 mile journey
to the local library. He rated searching and textual content as the top two with interactivity and aesthetics least important.

The more experienced subjects including those from a technical background showed naiveté in the way they used the package, especially in the searching strategies. None of the sample used the more complex searching facilities provided. Subjects showed little distress often associated with hypertext documents. This may be because of the leisurely pursuit of the information or because of ignorance of the scale of information available. Their inefficiency in use of a restricted information source raised questions on likely competence in any future use of the almost infinite information sources such as from the World Wide Web.

Conclusions

A striking conclusion after our in-depth look at a small number of subject is in the diversity of motivation and usage patterns associated with these products. Observed actions did not always match with stated importance of factors. The product’s status as being both a source of information and of entertainment makes it difficult to use a few key criteria for a successful evaluation, however, it seems that this is what tends to be done in the short reviews that commonly occur in the general and specialist popular media. Further work focusing on specific types of users would be interesting and would enable further refinement of the data collection methods utilised in this study. More controlled experiments may be useful in determining user competencies with the information products. Attitudes to and perceptions of systems like this are so dependant on non-technical issues that in-depth studies correlating the diversity of factors involved is likely to be the best way forward.

References

Networked, Asynchronous Student Evaluations of Courses and Teaching: An Architecture and Field Studies

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Abstract: As the number of courses offered via advanced telecommunications technologies continues to increase, so does the responsibility of properly evaluating the quality of the course content, activities, and delivery mechanisms. At many university, courses are evaluated via student evaluations. This paper describes a project at Victoria University of Wellington (VUW) that uses the World-Wide Web as an architecture for conducting student evaluations of courses and teaching and collating their results. We describe the organisational and technical issues that the design of our system needed to address, the system’s architecture and its implementation, and how the implementation attempted to resolve the tension between student anonymity, confidentiality, and privacy while guaranteeing user authenticity. We conclude with a description of three trial field studies of the system and a discussion of future work.

Keywords: evaluations, new applications, surveys, user studies, education.

Introduction

As the number of courses offered via advanced telecommunications technologies continues to increase, so does the responsibility of properly evaluating the quality of the course content, activities, and delivery mechanisms. At many university, courses are evaluated via student evaluations. Typically, these evaluations take the form of paper-based questionnaires in which students answer questions on a Lickert scale and, optionally, write in their comments. The results from such evaluations are important in improving the structure, content, and teaching of courses.

This paper describes a project at Victoria University of Wellington (VUW) that uses the World-Wide Web (Berners-Lee et al., 1994) as an architecture for conducting student evaluations of courses and teaching and collating their results. Using the Web to successfully survey users is not new (Pitkow and Recker, 1995). However, given the special importance of student evaluations and the protocol in which they are administered there are a number of issues that need to be successfully addressed.

We first describe the organisational and technical issues that the design of our system needed to address. We then describe the architecture of our system and its implementation using the WWW, Forms, and CGI-compliant scripts. In particular, we discuss how our implementation attempted to resolve the tension between student anonymity, confidentiality, and privacy while guaranteeing user authenticity. Prior research has shown that student evaluations must preserve anonymity if their results are to be reliable and valid (Feldman, 1979). Yet, our system must be designed to only allow access to valid users (students enrolled in the course) and must only accept one response per valid user.

We conclude with a description of three trial field studies of the system, involving students enrolled in Information Systems courses in the Faculty of Commerce and Administration at VUW. The first trial served as a proof-of-concept for the system. The second trial addressed potential biases that may arise in a networked evaluation system, as compared to the traditional paper format. The third trial addressed issues in asynchronous access to evaluations. In traditional course evaluations, students are administered evaluations as part of class time. Would asynchronous, remote access affect the kinds responses given and students' response rates?
Requirements of Evaluation Systems

Student evaluations play an important role within the University's infrastructure, so any evaluation system, whether paper-based or electronic, must be designed to satisfy several key requirements. These key requirements are derived from user, staff, administrative, and organisational considerations.

User perspective: the system must be anonymous, reliable, accessible and easy to use by students. It must be a system that they perceive as a serious vehicle for critical comments on their courses and lecturers.

Instructor perspective: the system must support flexible and tailorable design of questionnaires.

Administrator perspective: the system must guarantee several aspects of students’ responses. Responses must be anonymous. Prior research reports somewhat lower ratings when student responses are anonymous, especially if evaluations are administered before grade assignments are made (Feldman, 1979). Responses must be authenticated, confidential, and there must be no more than one response per user. Additionally, the system must be reliable and robust.

Organisational perspective: the system cannot incur substantial overhead, and must provide for useful, reliable and valid data on the ‘quality’ of university courses.


A traditional, paper-based system attempts to address many of the above requirements. Naturally, an in-class evaluation is accessible to students, and paper is, of course, a familiar medium. For staff, the system is flexible and tailorable, however this comes at the cost of requiring close interaction between the instructor and the evaluation administrator. There are also staff costs as they are responsible for distributing and collecting evaluations, then returning them to the administrator for collation and analysis.

Anonymity of response is preserved as students do not write their names on the evaluation form—although there is the danger, especially with smaller classes, that handwriting may be recognised. The paper-based system assumes authentication because the evaluations are carried out during normal class times—with larger classes especially, there is no guarantee that all persons present are valid participants in the course. Confidentiality relies on neighbouring respondents not looking over others’ evaluation forms. One response per student can not be guaranteed, especially amongst larger groups. Finally, data collation is expensive, incurring laborious and tedious data processing costs.

At VUW, a typical scenario has a course lecturer requesting teaching and course evaluations from the Student Evaluation Office, which assists the preparation of the questionnaire. The lecturer duplicates enough of the evaluation questionnaire to administer to the class. The lecturer delegates the actual distribution and collection of the questionnaires to students in the class. Evaluations are completed during class time. The completed evaluations are sealed in an envelope and either collected by the Student Evaluation Office or, with most evening classes, posted into the internal university mail.

WWW Implementation

Our pilot system addresses the above requirements as follows:

User perspective: the Web and HTML 2.0 with Forms provide a convenient, point-and-click interface for collecting on-line student responses. This means that the system is intuitive and easy for students to use.

The system is easily accessible by students as it is available via VUW’s campus-wide Web server, Panui. As the number of computer-labs, campus modems, and classrooms with network drops continues to increase, a cross-platform, networked, client-server evaluation system becomes the most viable solution.

Instructor perspective: the system maintains the same flexibility as current paper-based evaluations. Future versions will seek to improve and enhance on-line construction of questionnaires.
Administrator perspective: our system was designed to guarantee confidentiality and anonymity of student responses, while allowing no more than one response per user. We were reluctant to use student identification numbers for controlling access to the system, as we felt this could compromise student anonymity. Instead, as we will describe, students were randomly assigned codes, which they used to access the system. Authentication was guaranteed because only enrolled students received an anonymous access code.

Organisational perspective: clearly, online collection and collation of data improves efficiency, reduces paper-related costs, and eliminates the possibility of data-entry error. The system provides a means to reduce staff workload, while remaining flexible and scalable.

Student response data are automatically collated, processed, and logged via Common Gateway Interface (CGI) scripts that reside on the campus Web server. This provides a reliable and robust method of data collection.

Architecture

A typical user scenario conveys a sense of the interaction with the system. First, the student is randomly given an access code and a URL pointing to the evaluation entry screen, and access to a Forms-compatible Web browser. This entry screen presents a password type-in box into which the student enters the code. If the code is both valid and unused, the student is then presented with the first evaluation. After completing and submitting the first evaluation, the student is either presented with a “thank you” note, or presented with the next evaluation. This continues until all required evaluations for the student's course have been completed.

![Diagram](image)

Figure 1: Architectural components on the Web evaluation system.

Implementation

In choosing the Web as our evaluation infrastructure, we were presented with several architectural challenges. The first challenge involves allowing access to the correct course or teaching evaluation by authorised students only. Moreover, access must guarantee anonymity of student responses, while allowing no more than one response per user.

Student anonymity is implemented by randomly assigning a code to students from a pre-determined list, which they use to enter the system. Since the codes are randomly assigned, it is impossible to determine what responses were made by particular students. The list of valid codes is stored in a database on the Web server, and subject to the usual Unix file system security. Each response code has pointers to both the unfilled and completed evaluations. If the code entered by a student is valid and unused, the unfilled evaluations are presented to the student. Once the student has completed and submitted an evaluation, responses cannot be changed. Furthermore, the present pilot system does not gracefully handle system crashes or students who may have lost or forgotten their access code. While we are not entirely satisfied with the present approach, we have yet to determine a better and more reliable solution that also preserves student anonymity.
The second challenge involves the infusion of state information into the stateless HTTP protocol. This is required to keep track of students based on their code. Following an earlier approach (Pitkow and Recker, 1995), we use the hidden attribute of the TYPE field used in input forms in HTML 2.0. This attribute passes state information from a form to a CGI program in a way that is invisible to users.

The evaluation system resides on the VUW’s campus Web server, Panui, a DecAlphaServer 1000 running OSF1 and operating NCSA’s HTTP server, version 1.3 All CGI scripts are written in GNU C. All forms use the POST method in order to avoid hard-coded limits on the length of URLs that are present in some browsers.

The first script, the Code Checker, checks the code entered by the student against its database of codes. If the code is valid and has not yet been used, the student is allowed to proceed. Otherwise, an error message is returned to the user via an HTML file.

Upon entering a valid code, the Evaluation Presenter script is executed. Using database information, the script determines which evaluation to present. The evaluation contains radio and menu selection buttons, and text-entry boxes. Once the responses are submitted by the student, the data are then collated and stored in a file. Button data are stored in matrix format, while text-entry data are stored in a separate file. In order, student are presented with the requisite evaluation forms for their course until they have all been completed.

Responses submitted by students are collated in machine-readable format in secure files on the Web server. After each evaluation period, these files are downloaded by the Student Evaluation Office, and processed by their evaluation software.

Field Studies

The First Field Study

In the first study, 13 students completed a lecturer evaluation. The evaluation contained 8 questions, drawn by the course instructor from the University's standard question database. As with all evaluations, questions were answered on a 5 point Lickert scale, from “1. strongly agree” to “5. strongly disagree.” This was implemented by using radio buttons and menu selections. This first evaluative study served primarily as a feasibility study of the technology.

The Second Field Study

In the second study, 69 students completed course and lecturer evaluations. The evaluations each contained 8 questions on a 5-point scale, again selected by the course instructor. In addition, the course evaluation contained to text-entry boxes, into which respondents could type comments.

The second study was used as an opportunity to compare possible differences between students’ ratings using computer-based versus paper-based questionnaires. Half of the students were randomly assigned to complete the lecturing evaluation using the Web-based system, followed by the paper-based course evaluation. The other half first completed the paper-based lecturing evaluation, followed by the Web-based course evaluation. In this way, all students provided responses using both media.

The primary purpose of the second study was to determine if the medium used for the evaluation (paper vs. computer) affected student responses. None of the analyses performed showed significant differences between media on students' responses to the two evaluations.

Three statistical analyses where performed. First, a repeated measures ANOVA with evaluation questions as the repeated measure and medium as the independent variable showed no significance (both F’s < 1) for both evaluations.

Second, independent t-tests on responses to each of the questions for the lecturing evaluation showed no significant differences between media (all t's < 1). The course evaluation also showed no significant differences, though the response to one question tended toward significance. For reasons that are unclear, the students using the Web system gave slightly higher responses to this particular question, t(57) = 1.45, p = .15.
Third, because responses were ordinals on a scale from 1 to 5, we also performed a non-parametric analysis. Again, no significant differences were found between responses to the lecturing evaluation. Responses to the course evaluation showed no significant difference, except that, as above, the response to one particular question tended toward significance, $G(1) = 2.02, p = .15$.

In addition, after finishing the Web-based evaluations, students were presented with an additional form containing 2 radio-button questions. The first question asked students to rate the ease-of-use of the system; the second asked students to rate how well they felt their anonymity was preserved. As above, questions were answered on a 5-point scale.

Students appeared to find the system generally easy-to-use. Surprisingly, median scores indicated that many students felt that the system did not preserve their anonymity. Thus, despite our efforts, the “perceived” anonymity of student responses remains problematic. Further details of these first two field studies can be found in Recker and Greenwood (1995).

The Third Field Study

The third study investigated issues in remote, asynchronous administration of student evaluations. For this trial, we used a course in which students made significant use of networked and WWW resources. In fact, a post-hoc analysis of student network access showed that approximately 10 students in this course regularly used such resources. Seventeen students received, in a sealed envelope, a page detailing the URL of the evaluation page, details of when the evaluation was accessible, and a randomly-generated 4 digit code which they used to access the evaluation system. This code was used to only allow access to valid users, and to ensure no more than one response per user.

Overall, 10 students responded to the evaluations, yielding a response rate of 59%. Note that the number of respondents corresponded roughly to the number of regular network users in the course. This response rate also compares quite well to the average attendance rates in university lectures. In the authors’ own experience, response rates for the usual paper-based evaluations have ranged from 38% to 88%.

From a qualitative viewpoint, students’ written comments appeared to be more thoughtful and extensive than those normally received via usual paper-based evaluations. Since course time was not being used to respond, students may have taken a more thorough approach.

Finally, as in the second study, students found the system very easy to use. Unlike the second study, they strongly felt that their anonymity was preserved by the system. Perhaps the fact that students completed the evaluation at their leisure and in privacy contributed to this perception.

Instructor Response

All first two field studies were conducted with classes taught by one of the authors. For the third field study, a class was used that was taught by a lecturer who had planned no evaluation as they weren’t to be involved in the course in the future. All teaching participants were confident that no matter the outcome of the field studies, it would have little personal impact on them. The field studies were run to assess the viability of a WWW-based evaluation system. At this stage, there has been no research into teacher responses to the system.

Conclusions and Future Work

In this paper, we described a prototype Web system for conducting student evaluations of courses and teaching. We also presented results from empirical evaluations of the system involving approximately 100 students in 3 different courses. The results suggest that, overall, the system does not affect the reliability of students’ response. Students found the system easy to use, but, depending how the system was accessed, had different concerns about the anonymity of their responses.

Our pilot projects demonstrates the use of the Web in a real-world, time-critical task. There remain several issues and shortcomings which need to be addressed if we wish our project to penetrate successfully into the existing administrative and organisational culture of the university. In particular, long-term success depends on
demonstrating that the new approach offers significant savings over the existing system. People and organisations are reluctant to adopt new technologies unless expected benefits far exceed perceived costs.

Our approach demonstrates savings in terms of paper-related and data processing costs. While these are certainly important considerations, we believe that long-term penetration will best be achieved by the potential of offering evaluations that are free from time and place constraints. Beginning in 1996, VUW will allow full network access to all students from any lab on campus, and will offer increased remote access facilities. Thus, Web-based evaluations could be made available to students during specific time periods for students to complete at their leisure. With easy network access, students could complete the evaluations from a laboratory, or remotely from their home or place of work.

However, with remote access, steps must be taken to ensure that only enrolled students can complete the appropriate evaluations. Authenticated access will likely require the use of student identification and PIN numbers. While this method removes anonymity of response, confidentiality is maintained since the evaluation system is administered by a third party and course instructors only see aggregated results. This method would replace the “anonymous code” approach used in the pilot systems, which we felt was clumsy. It may be feasible to verify the students in a course from the registry enrolments database, and automatically generate random codes, which would be individually emailed to the students, along with details of the URL and the time window of access to the evaluation forms.

Finally, a Web-based evaluation system raises new issues in what is called the self-selection problem. No survey methodology is immune from the problem of biased results, which result from a skewed sample of the population choosing to respond to a survey. Electronic, “asynchronous” surveying is uncharted territory, and research is needed to identify potential biases that may arise.

References


Abstract: This paper describes the key ideas and the architecture of "A Learning Lab" (ALL) an interactive learning system designed and implemented at Istituto Tecnologie Didattiche to assist students in the learning of a given subject matter. In ALL the student is offered a pool of learning material pertaining to a given subject and the learning is a kind of reflective conversation with materials. This learning material, developed on the basis of a suitable knowledge representation, embodies various learning strategies. The student can choose to navigate through this material with or without guidance from the system. At any given moment, the student can ask the system for a diagnosis of his/her knowledge state. Communication facilities are available for students to send messages to their peers or teachers about the subject dealt with by the system. Authoring facilities allow students to take personal notes and produce multimedia documents. Although ALL cannot be considered either a conventional hypermedia or AI system, it is nevertheless based on both AI and hypermedia approaches. The guidance and diagnosis functions rely on suitable knowledge representation and an accurate student model. The material is integrated in the system and accessed by means of a Data Base of Learning Material (DBLM). Free navigation is based on hypermedia techniques, where hypermedia nodes represent the topics of the knowledge structure, to which the learning material is associated.

Introduction

There are a number of research projects aimed at developing educational systems which fully exploit the potentialities of both hypermedia and AI technologies for facilitating learning [Kibby & Mayes 1992]. This paper describes one of these projects. In particular it discusses the key ideas and the architecture of "A Learning Lab" (ALL), an interactive learning system designed and implemented at Istituto Tecnologie Didattiche to assist students in the learning of a given subject matter. In ALL the student is offered a pool of learning material pertaining to a given subject and the learning is a kind of reflective conversation with materials. This material, developed on the basis of a suitable knowledge representation, embodies various learning strategies (tutorial, drill and practice, assessment, problem solving etc.). The student can choose to navigate through this material with or without guidance from the system. At any given moment, the student can ask the system for a diagnosis of his/her knowledge state. Communication facilities are available for students to send messages to their peers or teachers about the subject dealt with by the system. Authoring facilities allow students to take personal notes and produce multimedia documents.

Although ALL cannot be considered either a conventional hypermedia or AI system, it is nevertheless based on both AI and hypermedia approaches. The guidance and diagnosis functions rely on suitable knowledge representation and an accurate student model. The material is integrated in the system and accessed by means of a Data Base of Learning Material (DBLM) [Delta Project 1990]. Free navigation is based on hypermedia techniques, where hypermedia nodes represent the topics of the knowledge structure, to which the learning material is associated.

Key Ideas
ALL is an environment in which tools and a pool of learning material are available to accomplish the different tasks involved in a learning process. The activities which can be accomplished in ALL are the following:

Free Navigation in the Learning Material: the student can freely navigate the learning material using a suitable interface showing the subject matter structure and the associated Units of Learning Material (ULM) [Olimpo et al. 1990]. A DBLM allows management of and access to the units of learning material;

Assisted Learning: the student is guided by the system, which chooses the next topic to be dealt with and the most suitable unit of material to be studied;

Learning Diagnosis: on the basis of its student-modelling facilities, the system diagnoses the topics already mastered by the student and those still to be covered;

Communication: the students can post a message to their peers and/or teachers referring to the subject matter dealt with by the system or to the system itself;

Authoring: in ALL the difference between learning and authoring is not clear cut. At any given moment the student can produce multimedia documents which may range from personal notes to actual hypermedia systems. By the same token, production facilities are available to a professional author to produce or adapt learning material which can be integrated in the DBLM of the system.

Visiting the Learning-Lab:

Several tools are available to perform the above-mentioned activities.

Learning Material + DBLM

The learning material integrated in the system consists of both audio-visual sequences and educational software (tutorials, drill and practice, tests etc.) stored in the hardware platform. This material is accessed by means of a DBLM, which is a part of the system. As will be described later, the learning material is produced by an author on the basis of a given knowledge representation. The student can freely navigate this learning material using an interface which represents the subject matter structure. The learning material is also used:

• by the supervisor module, which, according to the student's state, chooses the most suitable material; and
• by the student modelling module to update the student's state.

Knowledge Representation

In ALL, the knowledge is structured as a hierarchy of nodes, each representing specific abilities and knowledge (i.e. a topic and a class of tasks associated to that topic). In this representation, if node B depends hierarchically on node A, it means that "achievement of B is necessary to achieve A" [Ferraris et al. 1984].

The Knowledge Representation is used in

• the authoring activity, to define the structure of the learning material associated to each node;
• the student-system interface, to access the learning material in the free navigation mode and to show the student's current state;
• the guided learning, to choose the next topic;
• the learning diagnosis, to choose the next question.

The Tester

This is the part of the student modelling facility responsible for updating the description of the knowledge that the student is believed to possess [Self 1992]. It keeps the student profile up to date and involves:

• a representation of the topics already achieved and those still to be learned (overlay model);
• a hypothesis on the student's learning style [Pask 1976];
• a record of past interaction between the student and the system.

This module is used by both the student and the supervisor: the former to self-assess his own knowledge (for instance after a browsing section), where the topic for assessment can be selected either by the student or by the system; and the latter to decide the next topic and the associated material to be shown.

The Supervisor

This consists of a set of rules (described later) to decide the next topic and the material to be presented on the basis of the subject matter structure and the student's state [Delta Project D1012 1991].
The student can use these rules either to be guided during the learning process or to be advised on what to do next, for example during a free navigation section.

The Communication Facilities

This is a sort of electronic board. At any given moment, the student can post a message to his/her peers or teacher.

The Authoring Facilities

Several types of authoring facilities can be used: some are functions of ALL, such as those for assisting the author in designing learning material, while others are common personal productivity tools (e.g., word processors, graphic editors, hypermedia production environments, etc.) used in implementation. The author inputs a subject matter representation and for each topic the system produces the structure of the learning material. For diagnostic tests, for example, this structure shows the number of questions associated to each node and the knowledge required to answer them. The authoring facilities can be used at various levels of complexity: a professional author uses them to produce quality learning material, while a student uses them to produce personal documents which may be shared with his/her peers.

Using the Learning-Lab

We shall now examine how the tools described above are employed to perform ALL-supported activities.

In particular, we shall deal with free navigation in the learning material, guided learning and learning diagnosis. Petri Nets will be utilized for clarity of presentation.

Free Navigation in the Learning Material

This activity is based on selecting a topic for study (activity 1) [Fig. 1] and subsequently one of the ULMs associated to it (activity 2) [Fig. 1].

![Figure 1: Activities and resources involved in free navigation](image)

The topic is chosen using an interface which displays the knowledge structure [Fig. 2]. When a node is clicked, the student is presented with a pop-up menu listing the ULMs available for that specific node and their typology. Once a ULM has been selected, the system locates the learning material and presents it (activity 3) [Fig. 1].

[1]A Petri Net can be defined as a bipartite directed multigraph in which two types of nodes are represented: circles representing resources to perform or produced by an activity, and bars representing the activities.
Figure 2: The interface for accessing the learning material is isomorphic to the knowledge structure

Guided Learning

On the basis of the student model and knowledge representation, the supervisor decides which topic is to be introduced next [A Closer View of some Functions] and selects the ULM most suitable for its presentation (activity 1) [Fig. 3].

The study of the various topics using the associated ULMs [activity 2) [Fig. 3] is followed by assessment questions (activity 3) [Fig. 3], which are used both for deciding possible remedial activities and for dynamically updating the student model.

Learning Diagnosis

Considering the student model and the content structure, the system poses the student a number of questions aimed at assessing progress in his knowledge level.

In the following section guided learning and diagnosis are described with some more details.

A Closer View of some Functions

In the approach adopted, guided learning and learning diagnosis are only possible when the learning material stored in the DBLM has been developed using a methodology, called Delfi [Ferraris et al. 1984]. This methodology is based on a hierarchical representation of knowledge.

Knowledge Representation and Learning Material Structure

Here, if node B hierarchically depends on node A, "achievement of B is necessary to achieve A". In this representation there are two possible types of dependence between a node and its subordinates.
Referring to [Fig. 4] we may write:

a) \[ P(t)_A \rightarrow P(t)_B \land P(t)_C \]
b) \[ P(t)_C \rightarrow P(t)_L \lor P(t)_M \]

Where \( t_N \) is any task belonging to the N-task set (\( T_N \)) and \( P(t)_N \) is a predicate defined as follows:

- \( P(t)_N \) is TRUE if a task \( T_N \) is correctly carried out
- \( P(t)_N \) is FALSE if a task \( T_N \) is not correctly carried out.

Case a) indicates that any \( T_A \) task requires the performance of tasks belonging to both \( T_B \) and \( T_C \).

In case b), performance of \( T_C \) tasks does not imply the execution of tasks belonging to all the subordinate nodes.

The nature of the links determines the structure of the learning material associated to each node, as well as the supervision and diagnosis strategies. This representation makes it possible to determine both the minimum number of ULMs associated to each topic and their individual structure, which identifies the knowledge required to tackle the ULM. Both types of information are contained in a table, called the Item Table [Fig. 5] [Ferraris et al. 1984].

The Item Table is to be interpreted as follows:

- two items, A1 and A2, are associated to node A. The structure of item A1 entails making use of subordinate knowledge acquired under B, C, ..., L, ... Similarly, item A2 entails knowledge of B, C, ...,M;
- only one item is associated to node B, which involves knowledge of B prerequisites;
- etc. Following this guideline, the author will proceed to develop the courseware related to each item (learning material and assessment questions), which will then be stored in the DBLM.

**Supervision Rules**

When a student requests guided learning, the supervisor works on the assumption that his/her target is to get to the tree root. Consequently, the supervisor implements a learning strategy that backtracks node after node to the target node, starting from the student's present level of knowledge and learning style. How can the supervisor...
determine which node to start from? The key idea is that the student should go back through the hierarchy with minimum toil, which implies that:

- the choice of the topic sequence must be in accordance with his/her particular style of learning (holistic versus serialist) [Pask, 1976];
- the topics successively introduced must be consistent [Elsom-Cook 1992];
- simpler topics must be tackled first.

To these ends, the supervisor takes the following steps:

- prunes the tree by clipping off all nodes the student is already familiar with;
- starting from the root, locates the easiest branches and the node of departure. The complexity of a branch is determined in proportion to its depth (the number of hierarchical levels covered), the number of nodes forming it, the logical links expressing horizontal relations between nodes (and/or), the student's learning style, and finally, the estimated time required for learning each single node (as established by the author);
- having identified the departure node, the supervisor selects the ULMs to be tackled. This selection is currently based on the author's indications, integrated in the system.

This procedure recursively continues until all topics have been acquired or the student begins another activity.

The Diagnosing Strategy

At the outset of study, or whenever a student requests an assessment, the system runs a test session. This activity aims to provide a profile of the student's acquired knowledge (coinciding with hierarchy nodes) and what still remains to be covered. At the outset of study, the diagnosis task is used to initialize the description of the student's level. During interaction, the student can request an assessment either by:

- choosing a specific node in the hierarchy or
- letting the system select a node. In this case, the system selects the initial assessment nodes on the basis of the current student profile. The principle adopted is that the selection of nodes for evaluation is strictly linked to the student's record of past interaction (such as the topics dealt with during navigation, the amount of time spent on these topics, the topics already assessed, topics studied through guided learning, etc.)

The basic idea behind testing is that the student's level of knowledge should be updated through the minimum number of questions. To these ends, the number and type of questions posed by the diagnosing function dynamically depend on the student's knowledge. During diagnosis, navigation through the hierarchy takes place in descending order. If the student answers a given question correctly, the system assumes that s/he can also answer easier questions, namely those related to subordinate nodes. If, conversely, mistakes are made, the system goes on to asking questions of decreasing difficulty to spotlight the pre-required knowledge the student appears to lack.

Conclusions

The ideas presented in this paper seek to exploit the potentialities offered by the marriage of AI and hypermedia technologies for facilitating the learning process. The key idea underlying the project is that learning is the result of conscious interaction between the student and the learning material stored in the system. The student can navigate through this material in either a free or guided way and ask to be evaluated at any given moment. In order to be used in the system, the learning material has to be designed according to the design methodology and knowledge representation outlined in the paper. This representation is also used in the definition of guiding and diagnosing rules. So far a prototype of the system has been developed which implements the main functions. Future developments involve the implementation of all the functions and the testing of the effectiveness of the system with learning material related to various subject matters.

References


QTVR Aided Urban Design and Planning

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Abstract: The paper discusses the Quick Time Virtual Reality (QTVR) technology and its applications in urban design and planning context. Advantages of QTVR over traditional urban design and planning tools such as manual and instrumental drawing, computer-aided-design (CAD), geographical information systems (GIS), and photography are discussed. A general QTVR making process based upon still CAD/GIS images and real urban photos for effective urban design and analysis are presented.

Introduction

Urban Design is the physical and spatial design of the urban environment with a focus on the spatial relationship among individual buildings and the spatial interaction between the buildings and the site. Conventionally, urban design projects are heavily based upon manual and instrumental drawing. However, since the 1960's, computer-aided-design (CAD) and geographical information systems (GIS) have been widely adopted in urban design process. Although some CAD and GIS programs have animation capabilities, most of them are used primarily for generating static 2-D or 3-D drawings or maps. Recently, however, Quick Time Virtual Reality (QTVR) has been utilized in urban design and spatial form analysis, and the effectiveness of QTVR in assisting spatial urban design has been tremendous (Liggett and Jepson, 1993; Mitchell, 1995).

QTVR technology is related to Virtual Reality (VR). VR in urban design and planning describes a range of experiences that enable a urban planner to interact with and explore a spatial urban environment through a computer. These environments are typically renderings of urban spaces generated by GIS (i.e., Arc/Info) and CAD (i.e., AutoCAD) programs. To achieve the desired effects, most VR applications require specialized software and hardware such as high-end graphics workstations and stereo displays. As alternatives, some VR systems use video techniques to depict real-world urban scenes.

However, QTVR technology is different from VR in two respects (Apple, 1995). First, it is a system that allows microcomputer users to experience designed or real urban scenes using only a microcomputer with a mouse and keyboard. No specialized hardware or accessories are needed. Second, QTVR uses 360 degree panoramic photography technique that enables VR-like experiences of urban spaces. Instead of experiencing a static CAD or GIS rendering, QTVR can be used to create VR-like urban scenes based on a set of urban design images generated from CAD and GIS.

QTVR is based upon two new techniques: (1) a panoramic movie technology, which enables users to explore spaces. This approach can be used to create a VR scene showing the twists and turns of an urban Street. Users can move up and down the street, view a building, examine the individual buildings along the street. (2) an object movie technology, which enables users to examine physical urban elements such as buildings, roads, trees, people, vehicles, and topography interactively. Using an ordinary mouse, users can manipulate a building, turn it around to view different sides of it, and go inside the building.

A urban designer can combine panoramic and object movie techniques to create a vivid city. As the designer changes his view of a scene--turning left or right, looking up or down, or zooming in or out--correct viewing perspective is maintained, giving the illusion of actually walking around the city. Similarly, urban physical elements can be picked up, manipulated, and viewed from all angles while remaining in perspective. Pixel-accurate hot spots allow the designer to include various types of media click on a designated area of the scene, for example a video or audio clip, a still image, or a QTVR object movie.

Quick Time VR is specially good for urban planning students to learn cities and human settlements in remote sites or other counties. You can explore modern Manhattan in New York City, or examine the extent of the Great Wall in China--all without leaving home.

Advantages of QTVR

The QTVR software technology includes two components: (1) the QTVR Authoring Tools Suite, which is designed for urban designers to create new or existing urban scenes such as those described above, (2) the run-
time software, which provides the environment that designers need to experience QTVR on computers. QTVR's use of high-quality photographic images to represent urban environments, along with other innovations, results in significant advantages, which are described below (Apple, 1995).

High-Quality Images. Panoramic images for real-world urban scenes are captured using a 35mm film camera and a tripod rig, making expensive panoramic cameras and video production sessions unnecessary. Because of the greater resolution that film offers over video, QTVR images have richer color and sharper detail. And since 35mm cameras are more adaptable than panoramic cameras, various effects and diverse environments can be captured using an array of available lenses and filters.

Superior Realism. QTVR uses panoramic photography to capture real-world urban spaces. The software provides the correct perspective of every view in a urban scene in real time, giving the user the illusion of being there and looking around. Similarly, QTVR maintains correct perspective in complex computer-rendered scenes. QTVR object movies give the user the experience of walking, turning, and living within a urban scene.

High Performance. QTVR incorporates a new distortion-correction algorithm that is necessary to make the photographic-based realistic experience. The algorithm corrects distortion while panning and zooming, so horizontal lines appear flat and in correct perspective. The performance is independent of the complexity of the scene, and with no frame boundaries, panning and zooming appear seamless.

Ease of Use. QTVR allows the designer to look at any view of a urban scene or object through a simple, intuitive user interface. Previously, VR scenes of real urban spaces created through video techniques limited the designer to viewing the scenes in the sequence in which the video was recorded. With QTVR, designers have the freedom to easily move forward, backward, look up and down, left and right, and zoom in and out.

Small File Size. A single 360 degree view of a real urban scene captured on video would require tens of megabytes. By contrast, the QTVR process can store a complete 360 degree photographic representation of the urban scene in as little as 0.5 megabytes. Computer-rendered urban scenes require even less storage.

Flexible Interaction. QTVR's built-in hot spots allow the urban designer to make any part of a 360 degree urban scene interactive. When a user clicks on a hot spot, a variety of media can be launched such as a still photograph, an audio recording, a text display, a video clip, or a QTVR scene or object.

Easy Accessibility and Compatibility. Most existing VR systems require the urban designer to have access to specialized hardware and accessories. However, QTVR runs on most QuickTime-capable Macintosh or Windows-based computers, it is accessible to a much wider range of users. Usually, no extra hardware accessories are needed.

The QTVR Making Process

The QTVR authoring process for urban design and planning requires an experienced, multi-disciplinary team in order to achieve the best possible results. Depending on the urban designer's project and the desired results, the process may vary slightly. Typically, the QTVR making process includes four basic steps (Apple, 1995):

Planning. The first step in authoring a multimedia urban design project with QTVR is project planning. During the planning stage, issues regarding image types (real-world images or computer-generated images), the number of nodes to be included within a urban scene for navigational freedom, the VR objects that can be picked up and manipulated, etc. have to be planned. Often, decisions involve a trade-off between creative preferences and resource limitations. If a fairly complex realistic urban scene needs to be created from photographic images, the following preliminary steps need to be performed: (1) drawing a urban plan to depict the layout of the scene and the location of each node; (2) marking the locations of the nodes with pins, stickers, or other materials to facilitate the photography process; (3) creating a scene log or notebook for use by those who are involved with the photo shoot and post-production to manage the production details; (4) story boarding each urban scene; (5) building a database that will allow the urban designer to track his/her project through completion.

Images Capturing. QTVR titles can be created either from real-world urban spaces that the designer photographs, or from CAD- or GIS-rendered images. Photography and rendering techniques vary depending on whether the designer is creating a panorama of a city or a building. The way the images are created will have no impact on the run-time speed. Any 35mm camera with a rectilinear lens can be used for QTVR photography. Typically, shorter lens (less than 15mm) rectilinear lens are good for indoor spaces. Longer lenses (28mm or 35mm), may be used for outdoor urban spaces. The tripod rig and the camera must be operated carefully during the entire image capture process. Alternative equipment configurations can work, depending on the scene being shot.

Panoramas. A panorama represents a 360 degree view that one would see by standing in a single spot. With QTVR, a 360 degree panoramic view is created by capturing a series of overlapping shots using a 35mm film camera with a custom tripod rig or video, digital, or panoramic camera. The advantage of using 35mm film...
camera is that it is more readily available, yields higher quality images, and allows greater control of the panoramic images. In addition, exposure can be controlled with greater precision. With using special lenses, such as wide or ultra-wide angle lenses, the designer can capture a range of urban scenes from downtown high-rise buildings to large open spaces in suburban areas.

To shoot a panorama, the tripod rig has to be positioned at a spot. The designer then photographs the 360 degree view by taking a series of shots by rotating the camera at a calculated number of degrees until a full circle is rotated. The number of shots is determined by the lens size of the camera and the orientation of the images. The adjacent shots have to be overlapped by 30-50% to avoid the event that one of the images does not turn out. If a QTVR scene is built from computer-generated urban design images, the designer can use any available CAD (i.e., AutoCAD, 3D Studio) and GIS (i.e., Arc/Info, MicroStation) rendering package to create a 360 degree rendered view of a urban scene, using the built-in tools that allows the designer to render 360 degree panoramas directly.

Elements of Urban From. The designer can capture real-world urban elements using a video, film, or digital camera. The technique is to shoot the object frames in sequence, using a coordinate system and automated rig to ensure that all possible viewpoints of interest are captured. QTVR object file sizes vary depending on how many frames or angles are captured. File sizes usually range from 200-400 KB per horizontal sweep of the urban scene, with 36 frames captured in each sweep. If computer-generated images are used for the urban scenes, the designer can use any 3-D CAD orGIS application to render images of the urban scenes from all viewpoints.

Digitizing Images. To make a QTVR movie from panoramas, the designer must digitize the images on a Macintosh or Windows computer. An object captured with a standard film camera can be digitized with a scanner or other standard input device. A real-world urban scene can be captured using a video camera, the designer can digitize and store images using software such as the QuickTime XCMD Suite.

Stitching Images. An MPW-based software stitches the individually digitized photographic or computer-rendered images into a single, seamless 360 degree panoramic PICT file. Once compressed, standard-resolution QTVR panoramic scenes are approximately 550K in size. The software can stitch and blend the images automatically, or the designer can use an interactive mode, which gives the designer greater control over the final stitched image. Once the panoramic PICT has been created, it can be post-processed by using an high-end image processing package (i.e., Adobe PhotoShop) or some freeware/shareware on the Internet (i.e., GraphicsConverter). The stitching procedure can be skipped if images generated from a CAD/GIS application or from a panoramic camera are used. This is because these images output panoramic views automatically.

Creating Hot Spots. QTVR technology allows urban designers to interactively study urban scenes through hot spots. Hot spots can trigger a variety of actions, including launching a still image, playing a video or audio clip, displaying descriptive text, or launching a QTVR object. The designer can create hot spots using any commercially available or freeware/shareware image processing program.

Dicing Images. An MPW-based tool can be used to dice or compress panoramic PICT files and divide them into sections. The designer can select the type of compression, depending on the types of images (photographic, video, graphic, etc.). The software dices and outputs linear QuickTime MooV files that can be played back section by section.

Creating Single-Node and Multi-Node Panoramic Movies. Once the PICT files are compressed, the QTVR Authoring Tools Suite provides MPW scripts that are executable to create a single-node panoramic movie with interactive hot spots. The designer can also customize the resulting single-node panoramic movie by setting the window size and zooming scope for optimal viewing. HyperCard can be used as the tool for graphically editing urban scenes and creating multi-node scenes as well. The Scene Editor operates in node, link, and object. Node Mode allows the designer to add, delete, and position nodes in a scene. Link Mode allows the designer to create links between nodes that allow movie viewers to navigate. Object Mode allows the designer to link interactive objects. The final QTVR movie file supports playback on Macintosh and Windows-based computers. Movie file size depends on the number of nodes included. In general, movie files require between 500-700K per node.

Conclusions

QTVR is a powerful graphics and images visualization tool for urban design and analysis of urban scenes. The author's actual teaching and research experiences indicate that QTVR is superior to the conventional tools in urban design and physical planning, such as still photos taken in urban scenes and static images generated by CAD orGIS.

Care should be given to the entire procedure of QTVR making, particularly at planning, image shooting, image editing, and the final panoramic movie making. The overall QTVR effect should be VR-like representation of real-world urban environment. The number of nodes, the angles used for shots, hot spots, and inclusion of audio and video all contribute to the final QTVR visual effect.
References


Computers and the College Classroom: Two studies of Computer Training and Use Patterns

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Abstract: The Internet is a popular means of communication among college students, yet its application in the educational process has yet to be fully exploited. This paper reports the results of two studies which were conducted at a mid-size, liberal arts university. The first study evaluated Usenet newsgroups as a teaching tool in a seminar on death and dying. Despite some problems in training and computer access, students found it more useful than in-class discussion for certain types of material. The second study examined the issue of training in more detail. Two methods of familiarizing students with the Internet were compared: "hands-on" training versus lecture. Students, regardless of group, increased computer use over the semester. However, the "hands-on" group had a greater increase in time spent using newsgroups and computer library resources, as well as a higher perceived competence using computers at the end of the semester.

Introduction

The Internet is a popular means of communication among some college students, in the form of electronic mail [e-mail] and discussion groups [both synchronous and asynchronous]. Unlike the general public, faculty, staff, and students at many educational institutions can obtain access to the Internet free of charge. In addition to economic incentives, the popularity of Internet-based communication seems to stem from several other factors: a] the anonymity and privacy it can afford; b] its ability to provide quick and simultaneous contact with many others; c] the appeal of "advanced" technology that is both inexpensive and easy to operate; and d] access to a vast amount of information.

Despite the availability and popularity of Internet-based communication, its application in the educational process has yet to be fully exploited. At the university level, blame for this failure may rest in one of three places: the administration [failure to provide equipment, the absence of good technical support, etc.], the faculty, or students. Problems at the faculty level may include ignorance of computer technology and resistance to changing teaching style. Students, as a body, may suffer from similar problems of ignorance, resistance to change, and/or access.

The overall aim of this paper is to examine the introduction of computers to college students in two different contexts. The first study concerned the use of computers as an adjunctive teaching tool, in a course in which participation in a class newsgroup was required. The second study focused on two different training methods to encourage Internet use among students, in a course in which Internet use was encouraged, but not required.

Study 1

One relatively easy way to introduce computerized communication into the educational process is as an outside-classroom adjunctive activity. This study evaluated a Usenet newsgroup as a teaching tool in an upper-
division seminar on death and dying offered in the psychology department at Southern Methodist University. It was thought that in a seminar on a topic such as death and dying, students might feel more comfortable discussing certain topics online, rather than within the classroom itself.

The class discussion group was set up via Usenet, rather than using e-mail. Usenet is a broadcast medium which contains both news reader programs for reading messages and news writing programs. Using e-mail, each class member would have had to compile a mailing list of all recipients before being able to send her first message, and would have to save or delete each message individually. Usenet, on the other hand, is set up so that each class member, upon subscribing, had automatic access to all messages. In addition, each message is automatically deleted upon being read, reducing maintenance time. However, Usenet messages which the individual desires to save can be sent to one's own e-mail address.

Method

Participants were 25 members of a seminar on death and dying. Twenty-four of the 25 students were women, and [83%] were juniors, seniors, or graduate students.

The first day of class, students who did not already have Internet accounts were required to get one through the campus computer center. The computer center also set up a Usenet discussion group dedicated for the use of class members. This Usenet system allowed student messages to be sent easily to all other class members, and also kept all unread messages organized by date, sender, and topic. The instructor initiated the process by breaking the course into weekly topics such as "euthanasia" and "American burial customs". Each week, one student was designated to write an introductory paragraph about the topic, using outside material and/or personal experiences, and bringing up at least one question or ethical issue. Once posted, other class members were required to contribute to the subsequent student discussion at least five times during the semester.

A self-report questionnaire was given to the students on the last day of class, to assess general computer literacy and to obtain valuative data about the Usenet component of the course.

Results

Data on use patterns were contrary to expectations in that only 15% of the class reported having "a lot" of computer experience prior to college, 36% students spent 2 or fewer hours per week using a computer, and only 24% had a campus computer account prior to course. In terms of computer use, 88% of the respondents used one for word-processing, 68% for library research, 48% to play games, and 40% to access the Internet.

Data were also collected on student experiences using Usenet. Of note was the fact that most students waited a full month into the semester before attempting to use Usenet [time ranged from logging on in the first week of class to never trying] and that only 28% were successful on their first try. Both the average number of posting attempts and attempts to read postings over the course of the semester was seven [range: no attempts–daily log-on]. The average percentage of the time posting was successful was 65% [range: 0%-100%], and the average percentage of the time attempt to read messages was successful was 81% [range: 0%-100%].

Students reported that the most helpful learning aids were instructional handouts and the hands-on instruction at Computer and Media Instructional Center. They reported that the least helpful method of obtaining help was calling the campus computer help-line.

In terms of evaluation of the activity, 80% of the students thought it was a worthwhile addition to the course. Students reported the activity to be worthwhile for the following reasons [in decreasing order of response frequency]:

1. I liked being able to post and read material like poems that would be hard to share otherwise
2. The messages were informational
3. The messages were entertaining
4. It felt more comfortable to discuss personal experiences on the computer than it would to say them in class
Main drawbacks, as reported by the students, were as follows [in decreasing order of response frequency):

1. It was too frustrating trying to use Usenet because it rarely seemed to work right
2. It was inconvenient to find access to a computer
3. The training was inadequate

Discussion

Two main conclusions can be drawn from the above results. One, the students were not particularly eager to use the new technology even after being taught how to use it. An average delay of four weeks between being taught and actually trying to use Usenet, as well as an average of only seven Usenet postings over a 15 week school semester [often only enough to meet the class requirement] reflects this. Second, the training that was provided does not seem to have been adequate. This is supported by the fact that most students waited weeks before trying to post or read a posting, and that only about a quarter of them were able to do this successfully their first time. Also, two of the three main drawbacks seem to relate to training issues ["It was too frustrating trying to use the Usenet because it rarely seemed to work right", "The training was inadequate"]

In terms of evaluation of the activity, although the evaluations were overwhelmingly positive, some issues did emerge. First, some less computer literate class members reported that extra training might have led to increased participation. Second, the message writing program we used proved difficult to use, and discouraged some students. Third, access to the Internet required students to go to the computer center (none had a modem for their personal computer), an extra trip some were unwilling to take. Finally, using an Internet discussion group required additional time and effort on the part of the instructor, in terms of setting it up and monitoring it.

Despite the aforementioned problems, our conclusion is that this activity added substantially to the course. In contrast to the content of in-class discussions, students used the online discussion group to convey highly personal stories and to share material like poems and scriptures. The course instructor used the discussion group not only to comment on individuals' postings, but to post information relevant to the course [reminders of when assignments were due, etc.]. In addition, valuable supplemental teaching material was obtained from student postings.

Study 2

This study examined the issue of training in more detail. The following two questions were addressed: What are the use patterns of students in an upper-division psychology course?; and, does the type of training students are given effect their use patterns and attitudes toward computer use? To address these questions, two alternate methods of familiarizing students with the Internet were compared: "hands-on" training versus lecture.

Method

Participants were 42 students in Abnormal Psychology, who participated as part of the course requirements. A questionnaire on attitudes toward computer use in education and current computer use patterns, developed by the authors, was given at the beginning and at the end of the semester. As an objective measure of actual Internet use, the number of log-ons for each students for each month of the semester was obtained from the university computer center.

Class members were randomly assigned to one of two "contemporary learning methods in psychology" groups to meet outside of class time. The hands-on training group attended two two-hour sessions on using the Internet at the campus Center for Media and Instructional Technologies. The following topics were covered:

Hour 1: Introduction to Internet, how to use e-mail program
Hour 2: Mailing lists, network etiquette  
Hour 3: Usenet  
Hour 4: Introduction to software used to access the World Wide Web

The lecture group met for two two-hour sessions of lectures and discussions about educational technologies. The participants in this group were given the same handouts and information about the Internet, e-mail, Usenet, and Netscape as in the hands-on group. The main difference was that the lecture group did not have the opportunity practice the concepts on personal computer terminals during the sessions.

Throughout the semester, students were provided opportunities to get information related to the class [i.e., quiz answers] and to complete class assignments either via the Internet or via conventional methods [i.e., turning in a written paper, going and looking at posted information].

Results

Table 1 presents the demographic and pre-training use pattern data for the 42 participants.

Average age of participants: 22 years (Range: 18-49; SD= 6.41)

Sex::  78.6%   Female       21.4%   Male

Ethnicity:
81%   White
5%    Black
14%   Other/Mixed Race

Year in college:
21%  Second
41%  Third
31%  Fourth
 7%   Fifth or more/graduate student

Own a personal computer:  76%   Yes       24%   No

SMU Computer account prior to course:  36%   Yes       64%   No

Self-described computer expertise:
12%   None
26%   Very little
55%   Some
 7%   A lot

Computer use at the beginning of semester:
98%   Used a computer for word-processing
52%   Play games
48%   Library research
43%   Other (e-mail,newsgroups like Usenet, World Wide Web)

Modal amount of time using e-mail (per week):  < one hour
Modal amount of time using newsgroups (per week): none
Modal amount of time using World Wide Web (per week): none

Average number of hours a week using a computer: 4  (Range: 1-14; SD = 3.45)
Percentage of online time spent on following:

- 64% Time on word-processing
- 11% Time playing games
- 5% Time on library research
- 15% Other (e-mail, newsgroups, World Wide Web)

Table 1: Demographic and computer use of study participants (N = 42)

From the data in Table 1, a profile emerged of the typical computer user in this sample: someone who owns a personal computer, uses it for word processing, but who does not access the Internet much, and if she does, it is to use e-mail. Although 80% of the participants were juniors or higher in class rank, fewer than half had a campus computer account which would allow them free access to the Internet.

Attitudinally, students both perceived computer knowledge as important for their future, and expressed eagerness to learn more. Sixty-four percent of the respondents said they thought knowing about computers was very important for their future, and 72% reported being eager to learn more.

Taken as a whole, the class increased in both Internet use and perceived expertise over the course of the semester. At the beginning of the term, only 43% reported ever using the Internet. By the end of the term, 71% reported using the Internet. The record of actual log-ons supported this. The average number of log-ons in the first month of class was 11.5 (Range: 0-67; SD = 18.5), for the second month 19.7 (Range: 0-110; SD = 27.5), and for the third month 20.8 (Range: 0-116; SD = 29.9). Table 2 details similar increases in terms of perceived expertise.

Perceived e-mail expertise at start of course (n = 42):

- 43% None
- 19% A little
- 21% Some expertise
- 5% Moderate
- 12% A lot

Perceived e-mail expertise at end of course (n = 38):

- 14% None
- 12% A little
- 21% Some expertise
- 31% Moderate
- 12% A lot

Perceived newsgroup expertise at start of course (n = 42):

- 76% None
- 17% A little
- 7% Some expertise

Perceived newsgroup expertise at end of course (n = 38):

- 40% None
- 24% A little
- 26% Some expertise

Perceived World Wide Web expertise at start of course (n = 42):

- 83% None
- 3% A little
- 10% Some expertise
- 2% Moderate
- 2% A lot
Perceived World Wide Web expertise at end of course (n = 38):

45% None
17% A little
17% Some expertise
7% Moderate
5% A lot

Table 2: Pre- and post-training perceived expertise

Although overall increases in Internet use, regardless of training, were the most striking, some differences based on training method were also found. A series of one-way analyses of variance (ANOVA) were done. The hands-on training group spent significantly more time using newsgroups by the end of the semester than did the lecture group ($F(1,2) = 7.71$, $p < .01$). In addition, the hands-on training group spent significantly more time using computer library resources ($F(1,2) = 6.69$, $p = .01$). Finally, the hands-on training group reported significantly more perceived expertise using newsgroups by the end of the semester ($F(1,2) = 4.17$, $p < .05$).

Discussion

Several interesting findings emerged from this study. First, the participants were not as computer literate as upper-level students at our university are commonly believed to be. The overwhelming majority of them used computers mainly for word processing, and fewer than half had used the Internet at the start of the study. Second, although by the end of the semester those in the hands-on training group used computer library resources (which were not taught in the training) and newsgroups more than those in the lecture group, there was not the significant difference between training groups that had been expected. Rather, regardless of the training method, there was increased Internet usage across the semester as well as increased perception of competence using the Internet.

Since there was not a group that received no training, we cannot conclude that training, regardless of type, leads to increased Internet use and perceived competence. It is also not clear why the hands-on training should have only the specific benefits it did in the present study. What is clear, however, is that students both want and need training using the Internet, and that more studies attempting to elucidate the best methods are sorely needed.
Embedding Game’s Attractiveness into CALL System

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Abstract: This paper describes extracting the attractiveness of video game and embedding the attractiveness into CALL system through the development of a Kanji (Chinese character) compound CAI system. Learning a foreign language is important for world wide communication. However, the learners have to memorize much knowledge about foreign languages. It is a heavy cognitive weight for them and their learning will and motivation may decrease. In this paper we propose the utilization of Game style CAI called GATO-CAI in language learning. This type of system includes the attractiveness of video games. Attractiveness is a general term of interesting, attractive, charming and excited elements and we can embed it in order to enhance motivation and maintain learning will in GATO-CAI.

1 Introduction

Learning a foreign language is important for world wide communication. However, the learners have to memorize much knowledge about characters, words and grammar of a foreign language. If they especially learn a foreign language with hieroglyphic characters such as Chinese and Japanese, it is a heavy cognitive weight for them to learn those characters. In other words, the number of the characters often prevents them from learning the language and then their learning will may decrease. This is one serious problem in second language learning dealing with hieroglyphic characters.

The learners mainly memorize the characters by drill & practice as their homework when they study these languages with hieroglyphic characters. This type of study tends to be monotonous. Such memorization especially prevents learning will and makes learners to dislike language learning. The utilization of CAI is effective to assist them to memorize the characters, and some CAI systems have been developed. However, these systems do not put emphasis on learning will, but on learning ways such as drill & practice. In this paper we propose the utilization of Game style CAI system in language learning. The game style CAI system includes the attractiveness of video games. Attractiveness is a general term of interesting, attractive, charming and excited elements and we can embed it in order to enhance motivation and maintain learning will in game style CAI.

Introducing games into educational software has been already proposed by some researchers and therefore it is not a new idea. However, our idea has other new points, specially in extracting attractiveness from video games[Yano and Hayashi 93]. Video games are very popular to young people and they are known as a representative computer application with attractive elements and familiarity. The main point of our idea is to embed the attractiveness but not to implement game into CALL system. Some existing CALL systems have been developed based on traditional educational tools and games[Yeo 91, Qiu & Dunn 91] and they inherit the educational properties from them. These systems exactly have good educational functions but their facilities are not handled on general framework. Our approach, on the other hand, aims to provide a general way to realize an attractive CALL system. Therefore, our approach contains various kinds of questions, like: which attractiveness is used in CALL systems ?, how to embed the attractiveness into a CALL system ?, how to integrate plural attractiveness in CAI ? and so on. We call this type of CAI “GATO-CAI: Game’s ATtractiveness Oriented CAI”.

In this paper, we describe extracting the attractiveness of video game and embedding the attractiveness into CALL system through the development of Kanji compound CAI system called JULASSIC(Jukugo Learning ASSistance system with Computer game)[Hayashi et al 95]. Jukugo means Kanji compound constructed by two or more Kanji characters.

2 GATO-CAI
CAI never connects with game in the traditional view of education because CAI is considered for education and game is considered for amusement. Education and amusement are also thought as oil and water. However, there is a new educational view based on attractive learning connects games and CAI. Many people also think that attaching a game interface into a CAI system is constructing a game CAI system. Therefore in the past game style CAI has been defined as an educational system with a game interface. A part of GATO-CAI is in this category. However, GATO-CAI is substantially designed and developed based on game's attractiveness which enhance learning will and motivation. Although the following example is an extreme case, GATO-CAI does not have to adopt game interface as its learning environment. In a word, well embedding attractiveness into CAI system is more important than implementing game interface on idea of GATO-CAI.

3 Attractiveness of video game

We classified video games and extracted various kinds of attractiveness elements through questionnaire about video game. The questionnaire was conducted on 150 students of Tokushima University and Shikoku Junior College in Japan [Yano-Hayashi:93].

3.1 Classification of video game

We classified video game into eight categories; shooting game, action game, simulation game, puzzle game, adventure game, RPG (Role Playing Game), ARPG (Action Role Playing Game) and bodily sensation game.

3.2 Game's attractiveness

We extracted various kinds of attractiveness in video games through a questionnaire. We found the following typical elements of attractiveness. Although most of the attractiveness elements exist in traditional games without computers, high software control by the video game machine makes game's attractiveness more amusing and charming.

Time restriction

The element of time restriction is used in many video games because computer games can easily handle the time function by using the inner timer of the computer. Some games are progressing automatically according to the inner time and requires the players' actions and reactions through the game. The time feature is also used as conditions of game character's features. In "Super Mario Bros." (which is a very representative action game) Mario, who is the main character of this game, becomes invincible in a fixed period by getting the "star" character. This time restriction excites the game player and s/he wants the excitement from the time restriction. Although some traditional games without computer also include time restriction, video games can handle various kinds of time restriction compared with traditional games.

Level up

This is the typical feature of RPGs and ARPGs. The game characters in these games are operated by the game player and they become to be strong by acquiring "experimental point." The characters can get the point by beating monsters or completing quests. The amount of experimental point is essential parameter for deciding the character's level. The game player enjoys bringing up her/his characters in the game's world. The original RPG is in the category of board games without computer and a person called game master manages the game's progress, character's level, etc. However, the computer game avoids the load of game management from the original RPG, so the player can purely enjoy the character's level up without doing other work.

Stage clearing

This is the typical task of shooting games and action games. The world of recent shooting game is generally separated into some sub worlds called "stages." Clearing a stage brings the game player to the next stage of the game, which is generally more difficult than the previous stage. Clearing stage excites the game player so it is important as an attractiveness element of shooting game. In addition, many games allow the game player to select a stage or level of difficulty.

Puzzle
The element of puzzle is often embedded in various kinds of games. The puzzle plays the role of the gate of the game progress and the game player generally cannot go to the next stage or scene of the game without finding the answer to the puzzle. The game player enjoys finding the answer to a puzzle in trial and error, so interesting puzzle games attract the game player a long time.

Story

This is an important element of adventure games, as well as in RPG and ARPG. If the story is not exciting, the game player feels that the game is a dull game. The story is the essential point of attractiveness in many games. In addition, we can classify the role of the story into two types. One is for the background for the game player to understand the game world, and the other is the substantial element which constructs the game. The attractiveness of game relates strongly with the later role of the story. Although the story is important for attractiveness of the game, it is very difficult for general game developers to create good game story without help of a professional writer. This fact implicates that story making is out of engineering techniques.

Competition

This is very popular style adopted by many games. Two or more players can play in the competitive game in traditional games without computers. On the other hand, video game simulates some necessary players for game progress. Therefore the game player can play a competitive game alone. However, the attractiveness of competition is not in playing game alone but in fighting with other players in the game. The final goal of the game player is generally winning the game and the goal gives her/him high motivation.

Sound and graphics

These are the representative features of video games by using multimedia techniques. They are also extracted as the elements of attractiveness from all game categories. This fact suggests that sound and graphics are general attractiveness elements of video game. The game player feels attractiveness from beautiful sounds and colorful graphics. In order to realize high quality sounds, thousands color graphics, fast polygon animation and so on, many techniques are thrown into the development of video games. However, the most of the game players are not charmed by technical qualities of sounds and graphics such as sampling rate and the number of displayed colors, but the quality of their contents. We believe that it is very important point to realize attractiveness by sounds and graphics.

4 JULASSIC

In recent years, foreigners who are learning Japanese have rapidly increased, so that the shortage of facilities and teachers are the serious problems in Japanese education. CAI utilization is focused as one of this solution and some Kanji CAI systems have been developed[Bhatia 92, Hayashi and Yano 94, Nakajima 88, Walter et al 92]. The Ministry of Education of Japan indicates that the number of Kanji used in daily life are 1,945 characters, but this number is very large compared with that of alphabet characters. Therefore, it is said that Kanji learning is difficult for foreigners. Furthermore, Japanese use Kanji compounds constructed by two or more Kanji and the exact total number cannot be counted. However, it is generally said that the number of frequently used Kanji compounds is approximately two thousand. It is very hard to keep learning will and motivation for studying Kanji compounds for a long time. We think there are two types of assistance for Kanji compound learning by using CAI. One is to assists quick and effective memorization of Kanji compounds and the other is to enhance learning will and motivation. However, realizing the former assistance is very difficult because the memorization mechanism is not obvious. On the other hand, the later assistance can be realized by using game style CAI. It is generally known that game style CAI systems can give high motivation to learner and enhance her/his learning will. On the basis of these considerations, we have developed a Kanji compound CAI system called JULASSIC under the guidelines of GATO-CAI.

4.1 System design

The main point of system design is how to embed what kind of attractiveness in JULASSIC. We select "puzzle" and "competition" from extracted elements for game's attractiveness. The element of puzzle is to construct puzzle game which requires knowledge on Kanji compounds by the learner as the game player. It is appropriate for a novice learner to start to learn Kanji compounds because the puzzle game provides a trial and error environment for her/him. The element of puzzle helps in the introduction of Kanji learning and provides high motivation to the learner. We have designed a puzzle game environment as a learning environment based on the attractiveness of puzzle.
The element of competition is to enhance the learner's learning will. The learner's will to winning the game also gives high motivation. We adopt a Kanji scrabble game which has the attractiveness of puzzle and competition as the game of JULASSIC. Realizing such competition style of game, we introduced a computer player in JULASSIC. The computer player also has a role to control learning progress implicitly (this point is omitted in this paper).

4.2 Features of System

JULASSIC assists Kanji compounds (constructed by just two Kanji) learning and provides a game environment as the interface for Kanji compound learning. The game environment motivates and enhances learning will. JULASSIC provides a puzzle game called Kanji Scrabble Game. This is a derivative game from English Scrabble Game which is well known in the world. The Kanji Scrabble Game is improved in some points in order to use for Kanji learning. The most basic rule is competition between the human player and computer player by accumulating points constructing Kanji compounds. In this game environment on JULASSIC, the computer player and the learner locate a Kanji card on 5*5 matrix board each other. They can always have six Kanji cards and have to locate a Kanji card from them on the board for constructing correct Kanji compound from it and the adjoined Kanji card. The learner competes with the computer player by accumulating points in the game. For understanding and acquiring detailed knowledge of Kanji compounds, s/he can also search the meanings, pronunciations and usage of constructed Kanji compounds using the dictionary function of JULASSIC.

4.3 Test and comments

As for the evaluating JULASSIC, some students including Japanese test-used JULASSIC and we got the following comments:

(1) Competition to computer player is exciting,
(2) I had interested in Kanji compound learning,
(3) The computer player is too strong,
(4) I guess the computer player is not fair, etc.

Comments (1) and (2) are good comments for our system because the game's attractiveness contributes towards motivation and learning will. However, comments (3) and (4) are severe comments and we have to consider about computer player's level on Kanji scrabble game.

5 Conclusion

In this paper, we have described a new game style CAI called GATO-CAI, especially elaborating game's attractiveness embedded in CAI systems. In addition we have developed a Kanji compound CAI system called JULASSIC under the guidelines of GATO-CAI. JULASSIC embeds the element of puzzle and competition as game's attractiveness in the learning environment. As for the evaluation of JULASSIC, we got good comments for JULASSIC from test users. However, we found new issues concerning how to control the level of computer player from the test-use. We are presently researching on these issues as the next step in our work.

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References


Interdependence, 131-134.
Qualitative Diagnosis of Error-Based Simulation for Error-Visualization

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Abstract: We previously proposed a framework of a simulation which reflects an error a student made and makes him/her understand that his/her solution is erroneous in solving a mechanics problem. The simulation is called "Error-Based Simulation (EBS)." However, EBS isn't always effective for understanding an error and that in order for EBS to be effective, it should have a qualitative difference from a normal simulation (NS), instead of a quantitative difference. Therefore, it is important to diagnose the difference between EBS and NS in order to make use of EBS effectively.

In this paper, we propose a framework for managing EBS based on qualitative reasoning techniques. The module, which diagnoses the difference between EBS and NS, and then judges whether it is effective or not, is called the EBS-manager. We have implemented the EBS-manager and evaluated its effectiveness through an experiment.

1. Introduction

It is important for a student to understand why he/she made an error and what would happen based on his/her erroneous solution in problem solving in order to correct and prevent it from happening again. We previously proposed a framework of a simulation which reflects an error a student made in solving a mechanics problem[Hirashima 95a]. Irregular and unnatural behavior of mechanics objects reflecting an error helps a student understand that his/her solution is erroneous, because it visualizes implicit contravention of constraints in the erroneous solution. We call the simulation "Error-Based Simulation (EBS)" and to visualize the implicit contravention "Error-Visualization." We have implemented a generator of EBS (EBS-generator) and evaluated the effectiveness of EBS through an experiment.

However, the experiment revealed that EBS isn't always effective for a student to understand an error. When the difference between EBS and a normal simulation (NS) isn't a qualitative one, a student often cannot judge which behavior is correct. In order for EBS to be effective, it should have a qualitative difference from NS. For example, when an object (e.g., Ball) which normally falls down with acceleration "g" is erroneously falling down with acceleration "2g," it is difficult for a student to judge whether the behavior is correct or not. On the other hand, when the object is rising up with acceleration "g," it is easy for a student to judge whether the behavior is correct or not. Therefore, it is very important to diagnose the difference between EBS and NS in order to make use of EBS effectively[Hirashima 95b].

In this paper, we propose a framework for managing EBS based on qualitative reasoning techniques. The module, which diagnoses the difference between behavior of EBS and one of NS, and then judges whether it is effective or not, is called the EBS-manager. First, by using qualitative simulation[Kuipers 86], behavior of EBS is predicted and it is compared with behavior of NS similarly predicted by qualitative simulation. When a qualitative difference is found, EBS-manager judges that the EBS is effective for Error-Visualization. When a qualitative difference cannot be found, EBS-manager tries to find a parameter by using comparative analysis[Weld 88] of which perturbation causes a qualitative difference between EBS and NS. When such a parameter is found, EBS-manager shows the EBS with its perturbation. If such a parameter cannot be found, EBS-manager judges that EBS shouldn't be used for Error-Visualization.

We have implemented the EBS-manager and evaluated its effectiveness through an experiment. In this paper,
we also discuss the result and outline our future work.

2. Framework for managing EBS

2.1 Conditions for Error-Visualization using EBS

Figure 1 shows the framework of an Error-Visualization by EBS. EBS is generated by mapping an erroneous equation in formula-world to simulation-world. EBS shows irregular and unnatural behavior in contrast with the behavior of NS. The difference motivates a student to correct the error and provide useful information to do so.

The procedure to generate EBS we previously proposed is as follows [Hirashima 95a]: EBS-generator specifies the object which behaves in a strange manner reflecting the erroneous equation. The attribute "velocity" or "acceleration" is chosen in order to reflect the error to the behavior of the specified object. Then, value of the chosen attribute is calculated based on the erroneous equation and all the other values are calculated based on the normal equation. Therefore, an error in the erroneous equation is visualized as a strange behavior of the specified object. We illustrate an example of EBS with [Fig. 2]. When a student set up Equation-B as an equation of the Block, EBS based on Equation-B shows the Block ascending the Slope, while NS based on Equation-A shows the Block descending the Slope. It is a strange behavior, indeed, and a student can easily judge which behavior is correct and that Equation-B is erroneous.

However, in this procedure, no attention is paid to what kind of difference EBS has from NS. In some cases, it is difficult for a student to judge which behavior is correct. For example, in [Fig. 2], when a student sets up Equa-

![Figure 1. A Framework of Error-Visualization by Error-Based Simulation.](image1)

![Figure 2. An Example of Mechanics Problem.](image2)
tion-C. EBS based on Equation-C only shows the Block moving in the same direction as NS along the Slope at a little different velocity. In this case, it is difficult for a student to judge which behavior is correct and which equation is erroneous. However, when the angle of the Slope $\theta$ increases, velocity in EBS decreases while one in NS increases. Such a strange change in behavior enables a student to judge which equation is erroneous. On the other hand, in EBS based on Equation-D, when the angle of the Slope $\theta$ increases, velocity in EBS increases as the one in NS increases, that is, any strange change in behavior which enables a student to judge which equation is erroneous doesn't occur. Therefore, in such a case, it should be judged that EBS shouldn't be used for Error-Visualization.

Through this example, we can define the conditions in order for EBS to be effective for Error-Visualization as follows:

**Condition 1:** We say EBS is effective for Error-Visualization when there is a qualitative difference between the specified object's velocity in EBS and the one in NS, that is, the qualitative values (e.g. "plus", "zero", "minus") of their velocity are different. For example, in [Fig. 2], the qualitative value of the ascending Block's velocity based on Equation-B is "minus", while the one of the descending Block's velocity based on Equation-A is "plus." Therefore, there is a qualitative difference in velocity between EBS based on Equation-B and NS based on Equation-A, and we say the EBS is effective for Error-Visualization.

**Condition 2:** Even when there isn't any qualitative difference in velocity, we say EBS is effective for Error-Visualization when there is a qualitative difference between the specified object's behavioral change in velocity in EBS and the one in NS, that is, the qualitative values (e.g. "plus", "zero", "minus") of the ratio of their velocity's change to a parameter's change are different. For example, in [Fig. 2], since the Block's velocity based on Equation-A increases when the angle of the Slope $\theta$ increases, the qualitative value of the ratio of its velocity's change to $\theta$ is "plus." While, since the Block's velocity based on Equation-C decreases when the angle of the Slope $\theta$ increases, the qualitative value of the ratio of its velocity's change to $\theta$ is "minus." Therefore, there is a qualitative difference in behavioral change in velocity between EBS based on Equation-C and NS based on Equation-A, and we say the EBS is effective for Error-Visualization.

Here, we give priority to [Condition 1] over [Condition 2] based on the assumption that human can recognize the object's velocity more easily than the object's behavioral change in velocity. EBS-manager should diagnose EBSs and judge whether they are effective or not for Error-Visualization based on these conditions. In order to implement such a EBS-manager, we propose using qualitative reasoning techniques. We will explain its mechanism in the next section.

### 2.2 Mechanism of EBS-manager

In order to manage EBSs based on the conditions above, we need the techniques by which we can derive the qualitative values of objects' velocity and the ones of the ratio of objects' velocity's change to a parameter's change. By using qualitative simulation technique, the qualitative values of objects' velocity and the ones of the ratio of objects' velocity's change to time parameter's change (that is, acceleration) can be derived. By comparative analysis technique, the qualitative values of the ratio of objects' velocity's change to a parameter's change (except time parameter's change) can be derived. Therefore, we divide the error management procedure of our EBS-manager into two phases. In Phase 1, EBS-manager derives the qualitative values of objects' velocity and acceleration in EBS and NS, then compares them. In Phase 2, it derives the qualitative values of the ratio of objects' velocity's change to a parameter's change (except time parameter's change) in EBS and NS, then compares them.

Figure 3 shows the error management procedure of our EBS-manager. In Phase 1, the EBS-manager compares the qualitative behavior of the EBS with the one of NS and when a qualitative difference is found, the EBS-manager judges that the EBS is effective for Error-Visualization and shows the EBS to a student. When a qualitative difference cannot be found, it proceeds to Phase 2. In Phase 2, the EBS-manager tries to find a parameter of which perturbation causes a qualitative difference between the EBS and a normal simulation. When such a parameter is found, EBS-manager shows the EBS with its perturbation. When such a parameter cannot be found, the EBS-
The EBS-manager judges that the EBS shouldn't be used to visualize the error.

2.2.1 Phase 1 -qualitative simulation-

First, the EBS-manager predicts qualitative behavior of the EBS by using qualitative simulation and compares it with qualitative behavior of NS similarly predicted by qualitative simulation. When a qualitative difference is found, the EBS-manager judges that the EBS is effective for Error-Visualization.

By using QSIM[Kuipers 86], the EBS-manager derives the sequence of qualitative states based on an erroneous equation and similarly derives the sequence of qualitative states based on a normal equation. The qualitative state (we call it QS) consists of "qualitative value of velocity" and "qualitative value of acceleration". The sequence of QSs is described as \{QS_1, ..., QS_n\}. Let \{QS_1', ..., QS_n'\} be the sequence of QSs based on an erroneous equation and let \{QS_1', ..., QS_n'\} be the sequence of QSs based on a normal equation. Then the EBS-manager compares both sequences and searches for the interval in which \(QS_i\) has a qualitative difference from \(QS_i'\). When such an interval is found, the EBS corresponding to the interval is used to visualize the error.

Note that if there are several intervals in which \(QS_i\) has qualitative difference from \(QS_i'\), it is necessary to judge which interval is the most effective for Error-Visualization. The most effective interval means the interval in which \(QS_i\) has the most effective qualitative difference from \(QS_i'\). Currently, we give priority to velocity over acceleration. It is a heuristics based on the assumption in [Section 2.1] that human can recognize the object's velocity more easily than the object's behavioral change in velocity.

For example, in [Fig. 4] (initial velocity is added to the problem in [Fig. 2]), there are two intervals in which the EBS based on Equation-B has qualitative difference from NS based on Equation-A. In Interval-1 (I1), the EBS has qualitative difference only in acceleration. But in Interval-2 (I2), the EBS has qualitative difference in velocity and acceleration. Therefore, the EBS-manager judges that Interval-2 is more effective for Error-Visualization than Interval-1. In this case, the EBS-manager is sometimes required to adjust parameters to show Interval-2. For example, in [Fig. 4], if the length of the Slope (x0) is too short or initial velocity (v0) is too large, the Block in the EBS doesn't behave according to the sequence of qualitative states that contains Interval-2 because the location of the Block comes to zero before the velocity of the Block comes to zero. (Transition of location occurs before the one of...
velocity occurs.) Therefore, the EBS-manager should adjust the parameter x0 or v0 in order for the Block in the EBS to behave according to the sequence of qualitative states that contains Interval-2. Since QSIM cannot treat such a parameter adjustment, formulation of the method of the parameter adjustment is one of our important issues.

2.2.2 Phase 2 -comparative analysis-

When a qualitative difference cannot be found, EBS-manager tries to find a parameter by using comparative analysis of which perturbation causes a qualitative difference between EBS and NS. When such a parameter is found, EBS-manager shows the EBS with its perturbation. When such a parameter cannot be found, EBS-manager judges that EBS shouldn't be used to visualize the error.

After deriving the sequence of qualitative values of velocity based on an erroneous equation by QSIM, EBS-manager derives the sequence of qualitative values of the ratio of velocity's change to a parameter's change (we call it QD) by using DQ analysis [Weld 88]. It similarly derives the sequence of QDs with perturbation of the same parameter based on a normal equation. The sequence of QDs is described as \( \{QD_1, \ldots, QD_n\} \). Let \( \{QD'_1, \ldots, QD'_n\} \) be the sequence of QDs based on an erroneous equation and let \( \{QD_{1}', \ldots, QD_{n}'\} \) be the sequence of QDs based on a normal equation. Then EBS-manager compares both sequences and search for the interval in which \( QD_i \) has qualitative difference from \( QD_i' \). When such an interval cannot be found with perturbation of a parameter, EBS-manager runs the same process with perturbation of another parameter. When such a parameter and interval is found finally, EBS corresponding to the parameter and interval is used to visualize the error.

For example, in [Fig. 2], for Equation-C, EBS-manager cannot find any qualitative difference between EBS based on Equation-C and NS based on Equation-A by qualitative simulation. In this case, by using comparative analysis, \( \Theta \) is found as a parameter of which perturbation causes qualitative difference between EBS and NS. Increasing \( \Theta \) increases velocity of the Block in NS, while increasing \( \Theta \) decreases velocity of the Block in EBS.

Note that if there are several parameters of which perturbation causes qualitative difference between EBS and NS or if there are several intervals in which \( QD_i \) has qualitative difference from \( QD_i' \), it is necessary to judge which parameter or interval is the most effective for Error-Visualization. The most effective parameter means the parameter of which perturbation causes the most effective qualitative difference between \( QD_i \) and \( QD_i' \), and the most effective interval means the interval in which \( QD \) has the most effective qualitative difference from \( QD' \). Currently, we give priority to the difference between "plus" and "minus" over the one between "plus" and "zero" (or "minus" and "zero") in the value of \( QD_i \) and \( QD_i' \). It is a heuristics which seems to be adequate, but should be verified more strictly. It will also be our important future work.

In [Fig. 2], for Equation-D, EBS-manager cannot find any qualitative difference between EBS based on Equation-D and NS based on Equation-A by qualitative simulation. Moreover, in spite of comparative analysis, no parameter is found as a parameter of which perturbation causes qualitative difference between EBS and NS. In such a case, our EBS-manager judges that EBS shouldn't be used to visualize the error. We will discuss how to treat such a case in the next chapter.

3. Discussion

In order to evaluate the effectiveness of the EBS-manager as explained above, we have implemented it on computer and made an experiment. Using the problem shown in Figure 2 as an example, EBSs which were generated and managed by the EBS-generator and the EBS-manager based on the erroneous equations (Equation-B, Equation-C) were shown to ten subjects (college students). [Fig. 5] is the snapshot of simulations shown to the subjects where EBS and NS are shown at the same time. Upper simulation is EBS based on Equation-B. Lower simulation is NS based on Equation-A. In the case of Equation-B and Equation-C, most of them agreed that the EBSs well-reflected the errors in Equations and were useful in understanding the errors.

Our EBS-manager cannot find any qualitative differences in the case of Equation-D, currently. But in the experiment, three of the subjects indicated that changing the angle of Slope \( \Theta \) down to zero (means Flat Floor) or up to 90 degrees (means Vertical Wall) causes a qualitative difference. When \( \Theta \) becomes zero, the Block still moves at
gravity acceleration in EBS based on Equation-D, while the Block doesn't move any longer in NS based on Equation-A. And when Ø becomes 90 degrees, the Block falls down at infinite acceleration in EBS, while the Block falls down at gravity acceleration in NS. These are qualitative differences, certainly. Though changing a parameter to its limit is currently out of our method's range (because DQ analysis treats only perturbation that doesn't cause any changes in behavioral topology), like this case, checking the lower and upper limits of each parameter quantitatively and interpreting them qualitatively is a useful heuristic in order to find a qualitative difference. We are now trying to formulate this method.

Our another future work is to categorize qualitative difference and its effect. The effect of Error-Visualization by EBS depends on how strange it behaves. Therefore, in order to make use of EBS adequately, it is important to manage EBS, that is, to diagnose the behavior of EBS and to estimate the effectiveness of EBS. Since our EBS-manager often finds several kinds of qualitative difference by qualitative reasoning, it needs some kinds of heuristics to judge which qualitative difference is the most effective for a student to understand an error. We currently use a simple heuristics that the qualitative difference in velocity is given priority over the one in behavioral change in velocity. Though the experiment also supports that, it should be verified more strictly. For this purpose, it is necessary to analyse how human recognizes qualitative difference in behavior. This area will be the focus of our future research.

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Encouraging the Investigation and Solution of Real-life Problems with Mathematica & QBASIC

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Abstract: A classroom-based study was conducted to investigate whether Sec 2 or grade 7 (age 12 to 13) students will be able to develop critical thinking skills if they are allowed to discover problems about their living environment and solve real-life problems by using mathematical models. The students are from a Gifted pullout programme in a secondary school in Singapore. The students were introduced to new concepts such as variables, functions, function notations, domain, range, abstract functions, "patchwork functions", continuous and discrete variables using Computer Algebra System (CAS) software, Mathematica. Students used this knowledge to discover a real-life problem and solve it using mathematics modelling. Student group project and individual work were closely monitored and graded. Students were also assessed on Functions through a written test but were allowed to use Mathematica to solve the problems. A survey on students response to the program was also carried out.

The results of the study suggest that students enjoyed discovery learning but would prefer to be guided by teachers. They could appreciate the relevance of mathematics in real-life better. They displayed critical thinking skills in completing their projects but they did have difficulty with some of the test questions which required them to think critically.

Introduction

Calculators and computers are having a significant impact on math education [see Moursund 1995]. The potential of computer-as-tool is tremendous. With Computer-based tools now it is possible for teachers to give students more freedom to choose the type of problems they would like to solve as computers form a highly powerful tool for the numerical and graphical treatment of mathematical applications and models [see Hillel 1992; Kaljumagi 1992; Mathews 1992; Mayes 1993; 1995]. They need not limit the order of the polynomials or worry whether the polynomials are factorable. In turn, students are bound to find learning math more relevant and will apply these math and computer skills more frequently in their daily-life. Thus setting the stage for a life-long learning pursuit of math.

Currently there are a number of software packages in mathematics, such as Mathematica, that can combine symbolic and numerical calculations, plots, graphic programming into a unified interactive environment. Mathematica is not only used by engineers, scientists and applied mathematicians but can also be used in schools.

As a computer based productivity tool, students can easily use Mathematica to plot graphs instead of having to spend time plotting it by hand on a graph paper. Students can change certain parameters and notice the difference and come to their own conclusion. Thus students can spend more time on thinking how to solve problems rather than on mundane tasks.
QBASIC is a learner-based tool that allows students to create uses and applications of the tools that may not have been envisioned by the developer and permit expert users to develop sophisticated applications. In contrast to most computer-based learning software, learner-based tools can be adapted to fit the learning style of the student [see Bull & Cochran 1991].

Rationale

In Singapore, since the mid 1980’s when problem solving was introduced into the school mathematics curriculum there always has been a tendency to seek mastery of standard mathematical principles through “routines” and “procedures” applied to repetitive exercises [see Curriculum Planning Division 1990]. The effect of such imitative exercises may inhibit students’ thought processes and narrow their view of possible solutions, resulting in “inert knowledge”: propositional knowledge that students can express but cannot use [Whitehead 1929]. Students are taught these mathematical skills and are learnt sufficiently well enough for them to pursue higher levels of education. However, only a small proportion of these students apply these skills in their daily activities because they either do not have an interest in applying these skills or they do not see how these ideas can be applied in their daily life. Hence, very few of these students go on to become producers of knowledge.

For math to appeal to students, they need to appreciate the many ways it can be used today. But real life problems tend to be fairly complex. These problems can be solved by using mathematical modelling. However, real-life problems tend to involve complex mathematical equations with polynomials that are not factorable or limited to small degrees. This is where Computer Algebra Systems (CAS) such as Mathematica, Maple and derive can help. Together with the aid of Learner-based tools such as Microworld, Logo, QBASIC, VisualBASIC etc., students can present a fairly reasonable solution to some real-life problems that is relevant to them.

In a classroom situation, teachers are always fighting for time; to dabble in such discovery-learning techniques could cost even more time. Teachers could save time if they use computer-based aids such as Mathematica. It affords the opportunity for discovery-learning episodes by reducing the burden of computation, manipulation, and plotting so that students can be more productive. Using computer-based aids also allows for both algebraic and graphing approaches; these improve students’ understanding by furnishing multiple representations of a problem [Mayes 1995].

Method

The purpose of this study was to investigate whether students were able to discover problems about their living environment and express them using tables, graphs, algebraic expressions, and solve these real-life problems by using mathematical models. The study focused on how students could provide satisfactory practical solutions using the computer as a productivity tool. Students were to carry out activities independently with the teacher acting as a facilitator and solved similar exam-oriented questions using the productivity tool.

The emphasis was on using computer-based productivity tool, Mathematica, to learn Mathematics. Many of the activities were structured so that students could discover the results themselves [Barnes 1991]. Some activities were group-based but most required individual effort. Students, in groups, were also required to discover a real-life problem and solve it using mathematical modelling in groups. Students were allowed to use any software to solve the problem. All work completed by the students were graded. The students also answered a survey on their attitude towards computer-based tools and discovery-learning.

For this study, Secondary 2 (Grade 7, age 12 to 13) students in the Gifted Educational Programme were introduced to new concepts such as variables, relations and functions as shown in the lesson plan in Table 1. The lessons were conducted as enrichment in computer studies and was not part of their academic curriculum. The first four lessons were carried out during school hours and the last three during the term break. The students took a test on the above topic after school hours at the end of the programme.

Lesson 1 - Getting Started and doing a proper plot in Mathematica
Lesson 2 - Variables & Functions, and Curve Fitting with Mathematica
Figure 1: Lesson Plan

Exercises and Project Work

Students were competent in plotting graphs using Mathematica to complete the activities given. They were able to use Mathematica to fit a curve and predict what could happen in the future. They were able to communicate information by using graphs, tables and functions. They were also able to represent relationship that they encountered in their daily-life in the form of function notation, where it was possible. They were also able to differentiate between one-to-one and many-to-one functions. However, not all of them could decide correctly when a pair of variables is continuous or discrete. They also could not give original practical examples of functions in which the variable is discrete. They also could not think of real-life situations which could be a relation but not a function.

In projects, some groups came up with original ideas for their problems such as Predicting the chances you could get a book in your school library, Predicting how long a pop song will stay in the local charts, the best seating positions in a Computer classroom etc. All the projects were done using QBASIC and Mathematica was used to solve the mathematical models. The models were not sophisticated but were able to accomplish the task reasonably.

Analysis of Test

The written test (attached as Appendix A) comprised mainly of 'A' level(equivalent to 10th and 11th grade) questions on line graphs and functions. However, students were allowed to use Mathematica to solve the test questions and submit hard copies of their solutions. A total of 22 students sat for the test. The class average for the test was 61.2% and the class median was 67.0%. Most students could solve questions involving plotting a graph, finding the domain and range etc. However, only a few could solve questions that required them to apply the concepts in a different situation. For example, less than 30% of the students could add a straight line to a quadratic curve to find the roots of an cubic equation (Question 7 in Appendix A).

Only one student managed to give a good example to determine a rule for plotting a function f(x) given f(-x) (Question 6 in Appendix A). This could be due to the fact that the students have yet to master the skill of synthesizing information or they are still inexperienced in the use of CAS and computer tools. The students could have used Mathematica to verify the rule they finally settled on but instead settled on the first pattern they observed. This shows that students have yet to acquire higher-order thinking skills such as determining properties, examining extremes, using trial and error, and learning to monitor their own thinking [Van Devender 1992].

None of the students could find the inverse of the function f(x)= x - 1/x in the case where the domain is the set of positive real numbers (Question 3 in Appendix A). This is in spite of them being able to find the inverse of other functions (Question 5 in Appendix A) and being aware of the formula for finding the roots of a quadratic equation. This shows that the students were not very successful at transferring their learning experiences and applying to a new situation.

Analysis of Survey

The survey was carried out a day after the test was administered. All students agreed that plotting graphs and doing complex calculations is much faster with Mathematica. 14 (61%) out of 23 also found that they could solve Math problems more quickly using Mathematica. Therefore, the students feel that Mathematica has increased their productivity in solving math problems.
Almost all students agreed that they preferred to learn by experiencing the excitement of discovery, yet 61% said they preferred routine exercises. This could indicate that students want to experience discovery but without the extra effort and risk. Looking at another part of the survey, 52% have indicated they do not prefer to read a lot to learn new concepts in Mathematics. This could indicate the students prefer to be guided. This is further endorsed by the fact that 83% of the students do not prefer to use computer software to clarify some of their doubts in Math before seeing the teacher. This is despite the fact that 15 (65%) out of the 23 have discovered other ways of learning Mathematics using computer-based tools. However, 17 (74%) out of 23 disagreed with the statement ‘I have used computer software to understand certain Math topics better’.

61% of students agreed that they enjoyed discovering a problem and solving it using mathematical models. 61% also agreed that they can solve Mathematical problems more quickly using Mathematica. Yet 56% disagreed with the statement ‘I like learning Math using Mathematica’. This could be due to the command line interface of Mathematica and the necessity for the user to remember the syntax of Mathematica commands.

From the survey, it can also be noted that 22 out of 23 students are in agreement with the statement ‘Certain people can always see immediately how to solve a problem’. Also, 10 (43%) out of 23 students agreed with the statement ‘A good memory is essential for success in Mathematics’. These responses could indicate that students do not have the confidence in their thinking skills and have yet to develop the correct attitude towards critical and independent learning.

**Discussion**

Discovery-learning can be used in the classroom with productivity tools such as Mathematica by reducing the burden of computation, manipulation and plotting. Students are interested in solving real-life problems and solving it using mathematical models. They have done so by using QBASIC which can be considered a learner-based tool for these students as they have learnt it for more than a year. The real-life problems were mostly close to the hearts of the students. Students worked independently in completing the individual exercises. They used a variety of computer tools to complete their exercises.

The students in this study prefer to learn mathematics by experiencing discovery and solving practical problems but they want to do this without much effort or risk on their part. The students even when they are able to use computer-based tools to clarify some of their doubts and experience discovery, would prefer to learn about it in a structured programme from a teacher. The students are not very comfortable with viewing the teacher just as a facilitator although they have completed their projects independently.

Most students are able to apply the skills to solve questions at a higher level but almost none of them demonstrated higher order thinking skills in all the activities and test. Students unanimously agreed that Mathematica does save their time in solving mathematics problems. They are more comfortable clarifying their doubts from a teacher even if they could have done it using Mathematica.

**Conclusion**

Students do enjoy learning by discovery and computer-based tools do allow students to solve real-life problems close to their hearts within a short period. Students were able to solve certain problems they have not encountered. However, they have yet to master the higher order thinking skills such as determining properties, examining extremes, using trial and error, and learning to monitor their own thinking [Van Devender 1992].

**References**

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Appendix A

Computer Studies

Functions & Graphs using Mathematica

The Chinese High School

Name: Reg. No.: Class: Date:

Sec 2 Test #4 (GEP) Time: 90 min.

Q1-7 Answer all questions on an A4 size paper. You may use Mathematica to solve the problems and must attach your clearly labelled printouts for each question separately if you use Mathematica.

1. Use a function to model the relationship between the number of people sharing a fixed amount of money prize equally and the amount paid to them. Then
   (i) Decide which to take as independent and dependent variable.
   (ii) Express the relationship in function notation.
   (iii) Write a possible domain for the function.
   (iv) Sketch a possible graph of the function. [8]

2. Find the range of the following functions:
   (i) \( f(x) = x^2 - x \) if the domain of \( x \) is all real numbers
   (ii) \( g(x) = \frac{1}{(x^2-x)} \) if the domain of \( x \) is all real numbers except 0 and 1.
   Sketch, on separate axes, the graphs of \( f(x) \) and \( g(x) \). [8]

3. The function \( f \) is given by \( f(x) = x - (1/x) \) over the domain of all non-zero real numbers. Sketch the graph of \( f(x) \) and state the range of \( f(x) \).
Explain carefully how you can tell from the graph that, if the domain is restricted to either positive real numbers or negative real numbers, then \( f(x) \) is one-to-one, whereas if the domain of \( f(x) \) is not so restricted, then \( f(x) \) is not one-one. Find an explicit formula for the inverse function \( f^{-1}(x) \) in the case where the domain is the set of positive real numbers.

State the range of \( f(x) \) when the domain is the set \( \{ x: 0 < x^2 < 1 \} \).

Determine whether \( f(x) \) is one-one in this case.

4. Functions \( g(x) \) and \( h(x) \) are defined as follows:
\( g(x) = 1 + x \) for \( x \) is all real numbers,
\( h(x) = x^2 + 2x \) for \( x \) is all real numbers.
Find (i) the ranges of \( g(x) \) and \( h(x) \),
(ii) the composite functions \( h(g(x)) \) and \( g(h(x)) \), stating their ranges.

5. Sketch the graph of the following function together with its inverse: \( f(x) = (x+1)(x-1) \) for all \( x \) where \( x \) is a real number.

6. By sketching four graphs, state how a function \( y = f(-x) \) can be found if you have already drawn \( y = f(x) \). Using your rule, any curve \( y = f(x) \) can be drawn if you know the shape of \( y = f(-x) \).

7. Find the least value of the function \( x^2 + x + 2 \), and deduce the greatest value of the function, \( \frac{8}{(x^2 + x + 2)} \).
Draw the graph of the latter function for values of \( x \) from -3 to +3. By drawing on the same diagram a certain straight line find, to one place of decimal, two roots of the equation,
\( (x^2 + x + 2)(2 - \frac{1}{4}x) = 8 \).
Broadband Architectures For Arts Education: A Preliminary Study

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Abstract: Traditional arts instruction is rarely offered over distance learning networks beyond "appreciation" classes. I hypothesized that this was because current networks are modeled after television: one teacher is broadcast to dozens of students, limiting meaningful dialogue between teacher and learner. I conducted experiments around four scenarios from arts education to explore how students, teacher and artists could work together over a network where they could see and hear each other equally.

My tests were exploratory, but indicated that while equal communication channels allow artists, teachers and students to work together over networks, the challenge is to design networks and communication interfaces to support pedagogical goals. The short-term telecommunications infrastructure may best enable collaboration and critical review. In one-on-one teaching, students and teachers exchange subtle sensory information, and to support it requires re-structuring network architectures. Telecommunications deregulation opens up possibilities for more flexible systems that allocate communication channels as specific situations demand, and foster the creation of specialized network interface devices designed for specific educational goals.

Introduction

Distance learning networks rarely deliver traditional arts instruction beyond "arts appreciation." I hypothesized that this was because current networks are modeled after television: one teacher is broadcast to dozens of students in other locations. The teacher's video signal is sent out to all sites, while an individual student's image is embedded in a single wide-angle camera shot of an entire class. The ability for teacher and student to have a dialogue is inhibited by an inequality in communication - the teacher's ability to present is much greater than any individual student's ability to respond. Traditional education in the arts requires a much closer dialogue between student and teacher.

I conducted four exploratory tests to see what would happen when music students, teachers and musicians tried to work together over a broadband network where they could see and hear each other equally, but did not share the same physical space. I covered four scenarios that students and teachers of the arts commonly encounter:

- Critical Review - Professors responded critically to student compositions
- Collaboration - Two jazz musicians improvised together
- One-on-One Instruction - An experienced violin teacher and one of her advanced students who had been studying together for five years tried to conduct their normal lesson
- One-on-One Instruction - An experienced vocal coach and an advanced student who had never before worked together tried to conduct a basic lesson

My tests were exploratory, but indicated that while multiple and equal communication channels allow artists, teachers and students to work together over networks, the challenge is to design networks and communication interfaces to support the teaching-learning objectives.

Instruction in the arts requires teachers and students to exchange subtle sensory information. Students look to teachers as physical models for breathing and posture. Teachers listen and watch for very subtle qualities in a student's physical performance, or in the execution of a student's work. Changing the architecture of distance education systems to accommodate teaching-learning scenarios other than the lecture opens up the potential for networks to serve a larger audience with more diverse needs.
Methodology

I conducted four formal tests that covered a range of likely teaching and learning scenarios. The goal of the tests was to see how well each scenario fared in the networked environment, and to determine whether there were similarities as well as differences in the network requirements to support the scenarios. In every test, I used individuals who were advanced in their area. The teachers had all been practicing for more than 15 years, the students were classified as "advanced" by their teachers, and the jazz players were professional musicians who had been playing for more than 15 years.

Each test was conducted between two sites in separate buildings on the New York University campus. I used the Lightwave Systems analog video technology to send multiple channels of TV-quality audio and video over telephone lines. The bandwidth of the Lightwave System is equivalent to broadcast television - 6MHz for video, 22kHz for audio. Because of the short distances between sites, and because the system used analog technology end-to-end, there was no discernible delay in audio or video transmission between the sites.

Before I conducted the four formal experiments, I had to identify my research goals, choose sites on campus that would help me achieve those goals, and conduct preliminary tests to figure out how to use the network. For each test, I roughly followed the steps below:

- Identified the teaching-learning scenario I wanted to explore
- Recruited appropriate participants
- Interviewed participants before the event to determine the tasks they needed to perform
- Configured the network to support the needs of the participants
- Conducted the test
- Interviewed the participants to ask how effective the experience was for them
- Reviewed videotapes of the experiment

Results

The network worked best for collaboration and critical review, two teaching-learning scenarios that require less-demanding communication exchanges between teachers and students than one-on-one instruction. Collaboration and critical review could be successfully carried out over multi-channel communications networks that exist today, especially where delay is not a factor. To successfully support individualized instruction, communications companies must radically rethink network design and the transceiver configurations that exist on the user's end.

None of the participants felt that the environment precluded them from doing their tasks, although the music teachers felt the most effective use of the network would be in conjunction with what they do in face-to-face lessons.

All participants reported that they changed their behaviors to accommodate the environment. A study of the strategies that teachers and learners adopt within a networked environment is a rich area for research in its own right, and requires a study over time. My observations are limited to the issues that were revealed in a single session.

- The musicians jamming together had much greater tolerance for deficiencies in audio than the music teachers, who were listening for specific tonal qualities. The musicians preferred the setup that had better visual communication/lesser audio communication to the site that had lesser visual communication/better audio communication. It is possible that the musicians were able to mentally fill in the audio deficiencies, while the teachers needed to trust their ears to make critical judgments.
• To the musicians, video was an important component in building a sense of "presence," or clear communication channel, between them. They watched each other carefully on the video monitors and gestured at each other.

• The technology for picking up and transmitting subtle phenomenological qualities, such as the vibrato in a voice or overtones in a violin, must be built into the system for each scenario. One-on-one teaching and learning has much more specific and demanding requirements than collaboration and critical review.

• The position of video monitors relative to the position of the participant seems to be important. For musicians, monitors placed nearby added to a sense of presence; for teachers, monitors in a fixed location restricted their movement.

• Teachers were very aware of the need to switch camera views at specific points in the lesson. The teachers both wanted to see a specific angle on the student, and to show the student a specific visual angle. The musicians were satisfied with a single point of view, and were not aware of the need to show a specific view to each other.

• The need to work with cameras, monitors, microphones and loudspeakers to communicate with the remote site was somewhat inconvenient in all cases, but also presented interesting opportunities: one student made an impromptu music video to go with the presentation of his musical composition.

• It was the opinion of the music teachers that the networked environment may not be suitable for instructing beginning students, who need a physical connection to a teacher.

The Experiments

Critical Review

A class of graduate music students presented their compositions to an audience of music professors at another site. The students were in a small but very sophisticated audio production studio. During the session, each student said a few words about his or her work, played the recorded composition on a DAT player, then received comments from professors at the remote site.

We transmitted two channels of audio and video between each site. The two audio channels were very important because the students composed spatially for a stereo field - so the professors had to hear two separate channels of audio.

The environment successfully enabled each student to verbally present his or her work and play it so that the professors at the remote site were able to hear it in an appropriate manner, in stereo. The professors made a few comments and asked the students a few questions, to which the students were able to respond. The videotape shows most of the students and all the professors looking at the monitor most of the time, implying that the video component had some meaning for both groups. One student took control of the roving video camera during his presentation and made an impromptu "music video" to accompany his piece.

Collaboration

Two professional jazz musicians improvised together from different locations. Both musicians were trained in classical (structured) improvisation: one was an alto saxophonist and the other was an acoustic guitarist. The duo had played together once before. They played half a dozen songs together. Halfway through they switched locations. Site One had superior audio facilities, Site Two had better video facilities.

The environment successfully enabled the musicians to play together. The effectiveness of video seemed to be proved more in this experiment than any other. Both musicians communicated with each other using musical
conventions, making physical gestures such as nodding heads and pointing, and speaking to each other. Both watched each other on the monitors in both sites, although at the beginning of the session they both closed their eyes for a while to concentrate on the musical direction.

"The other place had better audio," the saxophonist said, "but I felt more like I was really playing with him here, with these two big monitors. I really felt his presence." At Site Two, the musicians sat on a chair in between two monitors, about four feet away, which were situated at the eye level of the musician. The monitors showed two different camera angles of the musician in Site One: a head-on shot and a view angled slightly to the right-hand side of the musician. Site One, by contrast, had a single large monitor placed about eight feet away from the musicians, and located on top of a five-foot shelf. A video bridge at Site One allowed the musician to switch between two views of Site Two, but both musicians chose a single view and left it there.

"I saw him better than I would onstage," the guitarist said, because lighting on stage may be poor and performers tend to face the audience instead of each other. At Site Two, the guitarist watched the saxophonist on the monitor and used physical cues such as stomping his foot and nodding his head to indicate the end of his solo where the saxophonist should come back in. He also spoke to the saxophonist, saying things like "come in at the bridge."

The saxophonist noticed a lack of true eye contact with the guitarist. Eye contact is a highly interactive form of communication that is very efficient for musicians. A glance at another musician conveys specific intent; an expression can convey emotional content; the intensity of a gaze communicates the seriousness of intent. The "interface" to eye contact communication is the most seamless interface there is, an important consideration for performers who are bodily engaged in their work. Faithfully mediated eye contact requires cameras to be built into display monitors.

One-on-One Teaching

I conducted two separate experiments: one with a violin teacher and advanced student who worked together regularly; one with a voice teacher and an advanced student who had never worked together before. The goals of the lessons were different, but the issues raised were similar.

In the first test, an experienced violin teacher and one of her long-standing students attempted to participate in a standard lesson over the network. Unfortunately, the audio signals going between the two sites were hopelessly mangled. The teacher could barely hear the student. The student could hear the teacher, but the audio was terribly distorted. They managed to carry out part of their lesson plan in spite of the problems and, in a twisted way, having problems helped identify the essential architectural qualities that would need to be present in a networked environment to enable a violin lesson.

The violin teacher felt that pitch and tempo were not obstructed by the malfunctioning equipment, but that the dynamics and tone qualities of the instrument were severely limited. The sound that she was able to hear from her student "did not project the vibrations of the violin itself, which is essential to the lesson process...."

Another problem was lack of physical space. "When you are teaching you need ... to walk around the student, while playing you need space to move." She felt that the cameras, microphones and the need to look at a screen restricted her movement. Her student also had problems trying to position himself toward the camera, move the microphone over the violin and watch the teacher on the monitor all at once.

In the second test, an experienced voice teacher and an advanced student who had never worked together before participated in a simple vocalization lesson. The teacher used a MIDI keyboard to accompany the student. The teacher also sang to the student to demonstrate what she expected. The student sang back to the teacher. Because they had never worked together before, the teacher focused on exploring the range of the student's abilities.

The environment enabled the voice teacher to work with the student and make some evaluation of her abilities. The student said that the teacher pinpointed the same issues in vocalization that her regular teacher did.
"It was more effective than what I thought it would be," the teacher said, "but it lacked the one-on-one physical contact" that she experiences in a face-to-face lesson. The teacher does not always make physical contact with her students in a live lesson as she tries to "see what they are doing with their tongue, jaw, and breathing." It is possible that increased control over the camera, or a visual map of the student's physical condition could fill in the gaps. She thought that more detailed visual information between student and teacher would help, "but can it take the place of face-to-face confrontation?"

"One of the things that I could not ascertain was a quality of voice," the teacher said. "There is a certain quality of the voice that determines physiologically what is being done incorrectly. The quality of voice is different" in a mediated environment. The student could hear the vibrato in the teacher's voice, but the teacher later said that she could not hear the vibrato in the student's voice. However, the teacher was certain that she could hear the "direction" of the student's voice.

DISCUSSION

The tests that I conducted were exploratory and designed to uncover areas of research that may merit further study. The more immediate questions, since broadband communication is in its infancy, is how can network architectures and user interface design evolve to accommodate needs and anticipate the future requirements of educators; and how will the impact of technology change what teachers and students do in the - real and virtual - classroom.

The telecommunications infrastructure as it exists today may enrich education in the arts simply by taking advantage of what already is available in non-traditional ways. For example, BRI-grade ISDN teleconferencing usually dedicates one channel of its two-channel system to TV-quality audio, the other to less-than-TV-quality video. Dedicating both channels to audio would create an environment that met the basic requirements of my experiment where the professors critically reviewed the musical compositions of the students who employed stereo spatialization effects.

The impact of signal delay on the effectiveness of remote communication decreases when participants are not trying to act in perfect synchronization. So, for example, an ensemble of musicians at one location could transmit their performance over a network to remote audiences. Individual audience members could exercise greater control over audio-visual qualities of presentation, such as hearing more of the vocalist and less of the guitarist, or zooming a camera view in on one performer. Current teleconferencing systems give limited control over these factors. Performance art companies, such as the Gertrude Stein Repertory Theatre in New York City, are beginning to take advantage of this capability by staging productions that combine on-site performers with artists from other parts of the world and teleconferencing them to several sites.

A camera is a recording device as well as a transmitter, and this fact can be exploited to assist the efforts of a distance learning student after the lesson is completed. A student can review a video recording of a lesson in a networked environment; if multiple camera angles are available, the student can review the lesson from several different perspectives. Mirrors integrated with video displays and cameras can reflect the student's real-time actions against previously recorded actions against the real-time response of the teacher to the student's actions. Taking the mirror-camera-monitor architecture a step further, it is possible that some instruction could be carried out asynchronously, where the teacher demonstrates a technique on video, the student records his attempts, and the teacher responds by editing together the first two recordings with a third recording of the teacher's actions interspersed with the student's. The system still must convey subtle phenomenological information, but it is perhaps easier to record the appropriate frequencies and visual angles than to transmit them in real time.

The communications interfaces I used in my experiments were not seamless. Participants had to speak into microphones, look into fixed-position monitors, work around cameras and mic stands, and watch out for wires. Better interfaces to these devices could have greatly improved the quality of communication between the teleconferenced sites, and new devices could be designed to address some of the specific issues raised by the participants:
• The violin teacher would have appreciated a multiple-footprint microphone that changed its polar response pattern on the fly, based on her need to move around.

• A camera built directly into a display monitor would have helped establish the illusion of eye contact between the saxophonist and guitarist in the remote jam session.

• The voice teacher wanted a closeup view of the student's jaw area to see the level of tension in her muscles. A camera view that allowed her to control zoom and pan of the student's camera could have been useful to her. A biofeedback device that could measure tension in the student's jaw and display it as a visual map to the teacher would provide another solution.

• Finally, easy-to-use controllers are essential for individuals participating in a teleconference to manage all of these capabilities. The industrial design of controllers must be created with specific tasks in mind: a drummer may prefer a footpedal control, a vocalist may use a controller built into a microphone stand, a saxophonist may appreciate a controller built into his instrument, an audience member may be satisfied with a device that resembles hand-held remote controls for television.

For illustrations and a more detailed discussion of these ideas, please visit my Web site at:
Implementing a Student Allele Database via the World Wide Web

(Extended Abstract)

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Abstract: We describe the design and implementation of the Human Genome Diversity Project’s Student Allele Database Facility and its interface via the World-Wide Web. The electronic lab bench is 80% complete at the time of this writing and can be found at [http://http.bsd.uchicago.edu/hgd-sad/].

1 Overview of the Project

The focus of this paper is the design and implementation of the Student Allele Database Facility and its interface via the World-Wide Web. The implementation of the electronic lab bench is 80% complete at the time of this writing. The curious are invited to explore [Database, 1996]. The Student Allele Database Facility is part of the larger Human Genome Diversity project which we describe in this section.

The Human Genome Diversity—Student Allele Database (HGD-SAD) will involve high school students from around the country in a long-term research project that illustrates many facets of the Human Genome Project. The project is centered around a hands-on laboratory that enables a student to produce a personal “DNA fingerprint” of the TPA-25 polymorphism on chromosome 8. In the schools, students isolate their own DNA from cheek cells obtained using a safe and simple mouth wash procedure. The crude DNA samples are then analyzed on site or passed to a partner genome research center for PCR amplification and separation of allele polymorphisms by agarose electrophoresis. If analysis is off site, photographs of the electrophoresis results are returned to the school.

Students determine their own genotypes and have the option of submitting their genotypes to a Student Allele Database maintained at The University of Chicago. Via the world-wide web, students can perform Hardy-Weinberg calculations and statistical tests to compare their allelic frequencies with those in the growing database. The addition of student populations from throughout America, Europe and, hopefully, other parts of the world will allow students to compare allelic frequencies in divergent populations and, perhaps, see evidence for genetic drift and evolutionary patterns.

HGD-SAD is a model for leveraging precollege biology instruction into the world of contemporary research. The project provides a cost-effective means to directly link students with human genome research and relegates appropriate team participation roles to high school teachers, genome researchers, database managers, and companies. HGD-SAD provides mechanisms to train teachers and research partners, as well as laboratory and computer infrastructures to facilitate participation by large numbers of students throughout the United States. The project extends the DNA Learning Center’s expertise
in developing laboratory curricula in molecular genetics and administering teacher-training workshops throughout the United States. It builds upon strong collaborations between the computational biology groups at Cold Spring Harbor Laboratory, The University of Chicago’s Biological Sciences Division, and Washington University (St. Louis); and the company laboratories of Roche Molecular Systems, Carolina Biological Supply Company, and the Porto Conte Research and Training Laboratories (Sardinia, Italy).

In brief the project aims to:

1. Develop an educational analog of the human genome project that “personalizes” gene technology and provides unique learning opportunities for high school students.

2. Provide an appropriate mechanism for increased collaboration between genome research centers and local schools.

3. Support a StudentAlleleReferenceLaboratory at the Cold Spring Harbor Laboratory.

4. Develop a StudentAlleleDatabaseFacility at The University of Chicago.

5. Conduct training experiences to introduce teachers and genome researchers to their roles in the project.

6. Develop curriculum materials to support the evolving project.

7. Provide bona fide scientific data on allele frequencies.

2 Student Allele Database Design Considerations

In designing the Student Allele Database our considerations fell into several categories. We implemented the Student Allele Database while paying close attention to such issues as hardware dependence; ease-of-use; novice vs. expert access modes; clear presentation of sophisticated analyses; the ability to use subsystems stand-alone; and ease of cooperation among students, teachers, and researchers.

- We wished that access to the software be as universal as possible. Many schools have only Macintosh computers while other schools have only IBM PC clone computers, thus we did not feel comfortable developing software that runs on just one of these platforms. We chose to implement the Student Allele Database via the World-Wide Web so that it would be available across many platforms — World-Wide Web browsers are available on Macintoshes, IBM PC clones, UNIX computers, and through many on-line service providers.

- Although many schools now have access to the Internet and the World-Wide Web, not all of them have high speed connections. We therefore implemented the interface so that it did not require a high data-rate connection. Although we have made use of graphs, charts, and artistic graphics, we have taken care not to use too many. Furthermore, wherever possible the interface makes sense even if the students use a text-based browser, forgoing all images. We were also aware that technology progresses more quickly than school budgets. We chose to freeze the web standard at HTML 3 (see [HTML, 1996]) and HTTP/1.0 (see [HTTP, 1996]). These are available from many web browsers, including Netscape 1.1 which is available free (see [Netscape, 1996]) to educational institutions.

- The differences between typical World-Wide Web applications and standard applications running on Macintoshes, Microsoft Windows, or the X Window System can be considerable. Often the way in which, for instance, menus are presented on the World-Wide Web is not intuitive to the users of these traditional platforms. We chose intuition over gimmickry to facilitate access to the Student Allele Database.

- We took into consideration the great variety among users of our software. In several places we have provided both a path for novices and a path for experts so that either a novice or an expert can take advantage of as much power as he or she can handle. This approach can be seen in both the data submission and data analysis sections of the software.
• Conceptually, simulations of data do not require the existence of tools for submitting and analyzing actual data. We therefore implemented the Student Allele Database to reflect this independence. Each of our data simulation tools can be used in a stand-alone mode. This allows use of the Student Allele Database simulation software in many situations and circumstances, even if they are barely related to Human Genome Diversity Project or the Student Allele Database.

• Learning does not take place in a vacuum. The Student Allele Database design reflects this by allowing communication between students, teachers, and researchers through its bulletin board. Through forms-capable World-Wide Web browsers the bulletin board is designed to allow participants to pose, debate, and answer questions on many topics. The designed bulletin-board interface allows participants to cite each other, particular data sets, or arbitrary web pages, easily and intuitively.

• Because we know that students and teachers may want to know more, we think it is necessary and have implemented the Student Allele Database with hyperlinks to genome resources around the world.

In the following sections we describe the Student Allele Database facility. The description cannot accurately reflect the actual interface and we strongly recommend that you explore it yourself. See [Database, 1996].

3 Data Submission and Editing

A classroom of students with their TPA-25 genotypes will want to put their data into the Student Allele Database. If they haven’t already done so, they first create a “group” in which their data will be placed. The group mechanism is convenient in that the students can later supply their group’s tag when running statistical tests if they wish to isolate those tests to their group only.

The group creation web page is a simple form that requests the country, state or province, and city of the group. It also requests the longitude and latitude of the group. These values can be used in later data analysis to restrict the data set being analyzed. The form includes a hyperlink to U.S. Census data so that groups in the United States that do not know the longitude and latitude of their city can look it up.

Once a group has been created the individuals’ data must be entered. This can be accomplished using an easy-to-use form that allows the addition, modification, or deletion of one individual’s data at a time. The instructions accompanying the short form are simple and explicit and even those who have little experience with computers will be able to enter their own data. Along with the genotype of an individual, the form requests information about race and gender. This information allows later data analysis based upon these categories. One of the goals of the Human Genome Diversity Project is the maintenance of the privacy of the participants and the entry form does not request any further identifying information.

If many additions or modifications need to be made to the group’s data, the bulk entry form can be used. It provides the entire data set for the group in one large edit-able area. The data may be modified in any way and resubmitted to the database. The associated instructions encourage the user to copy and paste the data from the edit-able area into his or her favorite word processing program. From there edits can be made with ease. The final data is pasted into the web browser and submitted to the database.

With these two input formats we have achieved our twin goals of providing both a simple but also a powerful way to enter data into the Student Allele Database. The simpler way can be used individually by each student as he or she enters personal data and later to modify that data if needed. The bulk entry method can be used for later corrections on a large scale, or for initial data entry if so desired.

4 Data Analysis

The data analysis tools allow any student or teacher to ask questions about the data — and get answers. The tools can be broken into two categories according to the number of populations analyzed. Several
tools take a population of the whole database or some subset and measure it or compare it to predictions. Other tools allow the student or teacher to compare two distinct populations to measure their similarities and differences.

After the user has decided how many populations will be analyzed, he or she is asked to describe the population or populations. A single web page allows the specification of one or both populations. The form allows the user to define the population by placing restrictions according to zero or more of race, gender, group tag, longitude, and latitude. The user leaves blank those fields for which no restrictions are desired but may enter values to specify ranges (in the case of latitude or longitude), or selects particular attributes (such as Asian, Black, Hispanic, Native American, and/or White for race). For ranges, two inputs boxes are supplied, one for the lower limit and one for the upper limit. For selections among multiple discrete possibilities a selection list-box is provided that allows the user to choose each selection by the click of a mouse.

Once the population or populations have been selected, there are several measures and/or comparisons to choose from. The tests and measures include those of Polymorphism Information Content (PIC), Entropy, Genetic Drift, and Chi-Square computations. When only a single population is analyzed comparisons of its genotype distribution to that predicted by Hardy-Weinberg Equilibrium are allowed.

The entropy and PIC measures are separate, though similar, methods for measuring diversity within the selected population. Each is a measure of how easy it is to determine whether two DNA samples come from the same person. The web page which presents the results of either measurement describes what the computed numerical value means. The discussion includes information to help place the numerical value in context: high measured values show that, on average, it is easy to determine that two samples come from different individuals but that low measured values mean the opposite. The discussion also gives the Entropy or PIC for the population under the assumption that the population follows the Hardy-Weinberg Equilibrium and compares that measurement to the actual measurement.

The Genetic Drift and Chi-Square comparisons compute the similarity or difference between two selected populations. The Chi-Square comparison computes the chi-square value and the p-value of the null hypothesis that the two populations are examples of subsets drawn from a single larger population. A high chi-square value and corresponding low p-value indicates that the two populations are dissimilar and that it is unlikely that their differences are merely statistical. The student is shown the calculation of chi-square and the implications of its actual value are discussed.

Genetic Drift is a measure of the number of generations that, according to a common theoretical model, one has to go back to find the common ancestor population. Similar populations will have low Genetic Distances while a pair of dissimilar populations will have a large Genetic Distance. The computed distance is displayed and its implications are discussed.

In all cases, the emphasis is on the qualitative implications of the measured value. Through questions, students are encouraged to discuss these implications with their teacher and classmates. They are encouraged to examine whether the particular measurement accurately reflects their class. The questions are presented along with the results and are tailored to be interesting in the context of the actual computed values.

5 Data Simulators

The data simulators provide a mechanism for students to generate fictitious populations and test them. Because this ability is useful even when a student is not part of a “real” population these simulators are designed to be stand-alone. They can be used by a student even if he or she knows nothing about the remainder of the Student Allele Database.

The simulators correspond to the measures and comparisons described previously. Each generates a user-specified number of sample populations according to user-specified parameters. These are measured or compared, as appropriate, and the data is plotted in a histogram. Using a simulator the students can get a real feel for the diversity among populations. They can see directly how normal a particular population is. They can see directly the extent that two populations are more dissimilar than other pairs of populations.

Each simulator is implemented as two web pages. The first is for user input and the second is for the simulator output. The input form allows various parameters to be specified. The set of parameters
depends on the simulation to be run but always includes, for instance the size of a trial population, and the number of such trial populations.

The output page shows the input parameters and the histogram of the results. It is designed to be compact so that it can be printed on a single page and turned in as part of a homework assignment. The Hardy-Weinberg Simulator (see [Hardy-Weinberg, 1996]) is now used as part of a Population Genetics laboratory at the University of Chicago even though that class does not otherwise interact with the Student Allele Database.

6 Genome Resources

It is hoped that students will take their experience with the Student Allele Database and the questions that it provokes and seek out further information. To ease the search hyperlinks to genome resources are available from the main Student Allele Database web page and also appear on other web pages in relevant contexts. We provide dozens of links to resources which fall into three primary categories: research genome resources, educational genome resources, and professional science organizations.

7 Bulletin Boards

The bulletin boards provide a place for discourse among students, teachers, and researchers. Discussions will be separated by topic and participation in one or more conversations is easily accessible through menu options. The full paper will discuss the bulletin board part of the Student Allele Database in more detail.

8 Conclusions

We expect full implementation of the Student Allele Database Facility, well in advance of the 1996-1997 school year. We are excited about the project, both as a tool for teaching biology as well as an example of how the World-Wide Web can be used to great advantage to bring cross-platform, computing power and database access to students throughout the country and the rest of the world. We strongly recommend that you take a look at the Student Allele Database web pages themselves [Database, 1996] to see what we are excited about!

9 Acknowledgments

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References

Understanding Teaching in the Video Conferencing Classroom

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Abstract: By the early 1990s the Australian Federal Government had restructured the university sector, creating a number of multi-campus institutions. In this context cross-campus teaching by video conference became a significant activity. Previous studies of teaching by video conferencing have concentrated on the impact of the technology, paying little attention to the full extent of the teaching and learning process situated in that context. The present paper examines how a sample of Australian university teachers understand the video conferencing classroom and how this impacts upon their teaching. It draws upon research into teaching and learning in the regular classroom, and argues that improvement in student learning in the video conferencing classroom will more likely result from a better understanding of the teaching and learning process, than by teachers acquiring a greater mastery of the technology.

Introduction

The fundamental issue for teachers in the video conferencing classroom is do they try to reproduce their classroom teaching in the electronic environment; or should they adopt a different approach? Cross-campus video conferencing requires groups of students to attend two or more classroom locations for scheduled classes where participants can communicate synchronously via audio and video links. Of all the new electronic technologies this environment provides the most difficult conundrum for teachers as it appears to combine the teacher-student arrangement and interaction of the regular classroom with the teacher-student separation characteristic of distance education.

One study reports that teachers continue to use traditional classroom teaching methods in the video conferencing classroom even when they do not believe they are effective [Gehlauf et al. 1991]. On the other hand, rather than being bound by previous practice, [Andrews & Bowser 1995] contend that teachers should use new technologies such as video conferencing to explore the potential to improve ways of teaching and learning. They claim, 'utilizing the new technology is about exploiting the characteristics of individual technologies to create new and exciting learning environments as opposed to replicating existing educational environments, environments which may not necessarily be successful in the first place and which were designed for education for the industrial age' (p87).

How, then, do university teachers comprehend the cross-campus video conferencing classroom? What does this mean for their teaching?

The present paper represents the initial stage of a more extensive study which investigates the relationship between how university teachers comprehend cross-campus video conferencing, their intentions for teaching in that situation, and their actual teaching strategies. [Prosser et al. 1994] claim that whilst studies of teaching strategies are common the 'intentions and strategies of lecturers need to be studied' in order to substantially improve approaches to teaching. The intentions and strategies of a teacher in the video conferencing classroom are grounded in that particular setting, which makes their understanding of it a critical factor in any examination of what and how the teacher teaches.

Contrasting conceptions of teaching by video conferencing

Previous studies of teaching in the video conferencing classroom assume that the predominant element in the teaching process is the technology and its impact on the teacher. These studies conceptually separate the act of teaching from what the student is to learn and how they are to learnt it. Teaching by video conferencing is seen to comprise a set of teaching methods and individual behaviour adapted to, or driven by, the dictates of the technology. An example of this conception of teaching is found in the study by [Schiller & Mitchell 1993]. They claim video conferencing,
'...requires a different teaching methodology from any that lecturers have used previously. The technology itself necessitates different ways of interacting, different ways of moving, different ways of presenting information and different ways of judging the meaning of the messages going in both directions' (p50).

Overall the research into video conferencing teaching can be divided into a number of areas including:

- the influence of the technology on teaching methods where the concern is with what the teacher does [Dillon, et al. 1991]
- the similarities and differences between face-to-face and electronically-mediated communication [Treagust et al. 1993]
- the instructional effectiveness of the technology compared to other distance education practices [Simpson et al. 1993], and compared to the regular face-to-face classroom [Whittington 1987].

The present paper has a different focus and draws upon the significant body of research into university teaching and learning within the regular classroom, and in particular one of the key principles underpinning that work. That is, that teaching and learning is a relational activity insofar as learning occurs in relation to teaching, and that neither aspect of this process can be conceived as existing independently of the other [Ramsden 1993].

[Patrick 1992] provides a unique way of perceiving the teaching and learning process as it occurs within the regular classroom setting. She depicts the process in terms of the relationship between the teacher, the student and what is to be learnt, describing this conjuncture as the object of study. It is a notion which originated in a study of high school teaching and learning but which has gained considerable currency in recent developments in the university teaching and learning field. The term refers to the way the teacher conceptualises their teaching task, what is to be learnt by the student, and how the student is brought into relation with that content. Patrick says,

'In the classroom, the teacher determines what is to be known, by what s/he focuses on, what s/he counts as appropriate knowledge, where s/he draws the boundaries of each topic...Teaching involves both the construction of an object of study, and bringing students into some sort of relationship with that object of study' (p2).

What the present study adds to the notion of object of study is a concern with the setting in which the teaching and learning process takes place. The research into university teaching and learning referred to above is confined to the traditional classroom setting. Within this literature issues related to the location and environmental circumstances of the teaching and learning process have rarely been considered. The emerging electronically-mediated teaching and learning environments which avoid simple classification as a classroom focus attention on elements of the teaching and learning process not conspicuous in the regular classroom. In these new teaching and learning settings the object of study may also be thought to comprise major environmental factors.

In the video conferencing classroom the composition of the class, the physical arrangement of the teacher and student participants, and the technological dimension may influence the teacher's understanding of the situation, and consequently affect their approach to teaching. For example, does the teacher's perception of their own role change if they understand the teacher-student separation to constitute a distance learning environment rather than some form of classroom teaching situation? If a teacher's enthusiasm for their subject is a key factor in the student's engagement with what is to be learnt [Ramsden 1993], then does this influence vary from the regular classroom, to a traditional distance education setting, to the video conferencing classroom? On another level the predominance of the television/video media which permits the teacher to monitor their appearance, and which is quite unlike the traditional classroom, may incline teachers to measure their effectiveness in terms of performance and presentation.

It must be stressed that recognising the technology's influence to be an aspect of the concept object of study is not the same as the approach of earlier technically-orientated studies of video conferencing teaching which isolate, and concentrate on, the impact of the technology.

Investigations into conceptions of teaching have highlighted a number of ways in which teachers see their teaching role and consequently expect their students to learn in conventional classrooms [Prosser et al. 1994, Martin & Balla 1991]. Both of these studies are located within phenomenography, a qualitative research method. [Marton 1986] explains that,

'Phenomenography is a research method adapted for mapping the qualitatively different ways in which people experience, conceptualise, perceive, and understand various aspects of, and phenomena in, the world around them' (p31).

Through the use of open-ended questions [Bowden 1994] says 'interviewees are encouraged to reveal, through discussion, their ways of understanding a phenomenon, ie to disclose their relationship to the phenomenon under
phenomenographic studies reveal that 'each phenomenon, concept or principle can be understood in a limited number of qualitatively different ways'[Marton 1986].

The study by [Prosser et al. 1994] focuses on the relationship between teachers' approaches to teaching and students' approaches to learning. It involved first year physical science lecturers. The study identified five approaches to teaching constructed from the underlying intentions and strategies of the teachers. These were described as:
- A teacher-focused strategy with the intention of transmitting information to students
- A teacher-focused strategy with the intention that students acquire the concepts of the discipline
- A teacher/student interaction strategy with the intention that students acquire the concepts of the discipline
- A student-focused strategy aimed at students developing their conception
- A student-focused strategy aimed at students changing their conceptions

[Martin & Balla 1991] studied the conceptions of teaching held by teachers undertaking an academic development program for university teachers. Their study identified three levels of conceptions and 'a number of differing perceptions that cluster around two of these different levels' (p298). The conceptions were described as:
- Teaching as presenting information
- Teaching as encouraging active learning
- Teaching as relating teaching to learning

The conceptions identified in each study are hierarchical with each list proceeding in order from less developed conceptions (at the top of the list) to more developed conceptions. Both of these studies provide a valuable insight into the way teachers think about their role in the regular classroom although neither study claims their respective conceptions are necessarily applicable to other contexts.

Methodology

Ten pilot studies have been conducted thus far, each involving a teacher and a group of students at one campus location linked by video conference for a formal class with a teacher and a group of students at another campus. The analysis presented here is based on five cases - three in nursing, one in science, and one in music. In each case the technology allowed participants at each campus to see and hear the participants at the other site. None of the teachers had received formal training in video conferencing teaching.

No attempt to select specific subject areas was made and the case studies were simply chosen from teaching being conducted at the time of the study. The two prerequisites for selection were:
(i) that video conferencing should be the principal mechanism by which the class was being convened for the duration of study in that subject
(ii) the teachers had experience teaching the subject in a regular classroom.

Qualitative interviews were conducted with both of the teachers in each case study. The teachers were interviewed with regard to a single, specific class immediately prior to conducting that class. In each instance the pre-class interviews addressed the following concerns:
- how does the teacher make sense of the cross-campus video conferencing classroom as a teaching and learning environment?
- what are the similarities and differences compared with the regular classroom?
- what does the teacher intend the students to learn?
- how will the teacher bring about student learning of that content?
- how will the two teachers work together in that class?

The class was then observed to determine whether their intentions manifested themselves in the actual teaching strategies employed. The teachers were again interviewed at the conclusion of the lesson. The teacher interviews have been analysed using phenomenographic analysis. In this study teachers' conceptions or ways of understanding teaching in a cross-campus video conferencing classroom is the object of analysis. The conceptions referred to below are an initial attempt to develop an understanding of teaching in the cross-campus video conferencing classroom.

Results
Preliminary examination of the data collected for this study indicates a close parallel between the conceptions of teaching held by teachers in the video conferencing classroom and those identified in the studies by [Martin & Balla 1991] and [Prosser et al. 1994] which were conducted with regular face-to-face teachers. This appears to be due to the fact that the teachers perceived the video conferencing classroom to be a relatively familiar environment in terms of the teacher-student relations. There is no evidence that teachers in the video conferencing classroom were concerned with the technical dimension of the environment to any significant extent, which is contrary to the assumptions underlying many previous studies. In fact rather than seriously influencing their approach, video conferencing seems to have accommodated the teachers' prior (classroom-based) approaches to teaching as far as the teachers themselves were concerned. This is consistent with the findings reported by [Gehlauf et al. 1991]. Whether the teachers could have better used the capacity of the technology in their teaching is a separate question not addressed directly in this study.

In all of the case studies the teachers believe they teach in exactly the same way in both the regular face-to-face classroom and the cross-campus video conferencing classroom. All of the teachers claim they make no change to what they teach and only very minor adjustments, if any at all, to how they teach (such as accommodating a different overhead display device, or reducing their movement around the room). Where teachers in the cross-campus video conferencing classroom conceive of teaching as the presentation or delivery of information, with students as passive participants, there appears to be no need to involve students at either of the electronically joined sites. However, where student involvement is seen as necessary to their learning more effort is made to engage both groups of students.

In three of the case studies (all nursing), the teachers described a didactic approach to teaching which manifested itself in their actual teaching strategies. In each instance one teacher assumed the leading role of instructor whilst their colleague at the other campus played virtually no part in the teaching process. In two of the three cases there was minimal opportunity for student involvement, and in the other case none at all.

In the first case the teacher proposed to display the entire lesson text on a television screen enabling students to read it at either site whilst she proceeded to read the material to the class. This teacher was overwhelmingly concerned with the content being delivered and consequently she gave little thought to her mode of presentation. She did not engage the students at either site in any way. This teacher attempted to provide students with as much information as possible and assumed that the delivery of the content is non-problematic; that students having received it, will make sense of it at a later stage. There are parallels here with Martin and Balla's content focus conception.

The second case study reveals a teacher who highlights her role as lesson presenter through role-plays to the class and who sees no need for student involvement at either site. This teacher places great emphasis on her performance as presenter. It is through the presentation that students come to know because its impact causes students to remember significant content and concepts. This parallels what [Prosser et al. 1994] describe as a teacher focused strategy with the intention that students acquire the concepts of the discipline.

In the third case, the teacher described her approach as interactive. It consisted of a lecture punctuated by frequent questions put to the class. The questions were intended to identify what the teacher considered to be key points in the lesson and to allow students to actively construct answers as a group rather than simply receive them in the teacher's presentation. However, the questions were conducted in a way which failed to recognise the need to provide opportunities for equal participation by the distance students. This teacher's approach assumed that students need to be actively engaged with the subject content for learning to happen. However, interaction in itself is not beneficial and must lead to the development of key concepts relevant to the subject and be of significance for the students. One of the approaches to teaching identified by [Prosser et al. 1994] as teacher/student interaction with the intention that students acquire concepts in the discipline, appears to be similar to this teacher's approach.

None of the teachers in the three nursing case studies thought of their relationship with the other participating teacher as collaborative. In terms of the teaching process, the arrangement of the teachers in the cross-campus classroom was generally understood as a local teaching site joined electronically with a distant receiving site.

In comparison, teachers in a science class saw the situation very differently to any of the nursing teachers. Their teaching was based on a conscious attempt at collaboration which consisted of alternatively providing a lecture from either site. In their attempt to actively engage students in their own learning this situation resembles the previous case study as an example of teacher/student interaction with the intention that students acquire concepts in the discipline [Prosser et al. 1994]. The teachers' equal involvement in the process helped to avoid a rigid sense of active teaching site and passive receiving site prevalent in the first three case studies.
This was also the case with a music class where the teachers' approach was based on generating student activity in an environment where the teachers aimed to create a facilitative and collegial approach to student learning. There is evidence here of Martin and Balla's category of teaching as encouraging active learning. Significantly, this was the only class investigated in this project where the students were expected to operate the video conferencing technology. In this class one teacher clearly dominated the preparation and conduct of the lesson which reflected that teacher's sense of original ownership of the program prior to the other teacher and student group becoming involved by video conferencing. This raises important questions about the design and ownership of programs when more than one faculty member is involved and the resultant staff dynamics when an existing single campus program is extended electronically to other campuses.

Discussion

Teachers conceive of the cross-campus video conferencing classroom in a number of ways. The critical factor is how the teachers make sense of the arrangement and involvement of the classroom participants. For example, in the science class the city-based teacher regarded the students as two distinct cohorts with the rural students being passive and difficult to involve in the class due to behaviour he attributed to their different domestic and educational location. This teacher understood this to be an obstacle to attaining a homogenous student response rather than an opportunity to enrich the learning process by drawing upon a wider diversity of experience. On the other hand, in this same class both teachers anticipated the value to students of alternating responsibility for presenting the lesson, thereby sharing the teachers' combined expertise with the extended student group.

The music teachers saw their situation differently to the science teachers. In this case both teachers recognised and welcomed that the two student cohorts differed in skills and knowledge in the areas of music theory and practice due to distinctions in formal courses undertaken previously at their respective campuses. It was their view that students at each location would benefit from an approach to learning based on the sharing of ideas and constant dialogue and interaction between classroom participants.

All of the nursing teachers viewed the electronically-linked locations as a form of large classroom, with the distant students equivalent to those at the back of a regular classroom. In this sense the students were seen to be only remotely present in the class.

Where the cross-campus video conferencing classroom is conceived as a teaching site/receiving site dichotomy, as in all three nursing case studies, the teaching process is skewed dramatically towards information presentation. In each of the nursing classes one teacher and an accompanying student group were perceived as passively receiving teaching from a dominant site, leaving the subordinate teacher to do little more than operate the video conferencing technology. When more than one teacher is involved in the class they should each play an active role in making student learning happen.

From the perspective of the individual teacher the complex social composition of the video conferencing classroom undoubtedly presents a number of difficulties in class management and the construction of the student learning experience. However, the benefit of synchronous teacher-student and student-student interaction associated with the traditional on-campus classroom experience can be enhanced by the creation of the extended video conferencing classroom. For instance, varying cultural and socio-economic perspectives and diverse experiences might be brought to the study of a subject in ways not possible in a regular university classroom through regional, national and international links. The number and location of participants may vary widely as experts and students in one corner of the nation or at one university might work with students and other experts or teachers at another location. As this study shows, how teachers make sense of the cross-campus video conferencing classroom will be an important factor in the realisation of its potential as a teaching and learning environment.

References


MASK: Multimedia Audit Situated Knowledge

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Abstract: The MASK project develops a self-paced interactive multimedia simulation for Auditing students that integrates the latest computer auditing tools into case studies within a 'real world' banking environment. This has the benefit of introducing state of the art tools into auditing courses which remain predominantly paper based and exposes information systems students to 'real world' auditing environments and techniques.

Learners will actively explore organisational auditing to discover how to identify, observe effects of, and report on auditing outcomes such as the detection of errors or frauds. Using high quality video, sound, graphics linked to a computer-auditing language students will build an understanding of how auditing models are organised into appropriate strategies for different work contexts and establish better links between auditing theory and practice in case-based scenarios. This will lead to a better integration of theoretical knowledge and increased ability to apply knowledge in practice.

1. Introduction

The need for an improved approach to teaching information systems audit investigations for Information Systems (IS) students emerged from curriculum reviews and feedback from industry, employers and international auditing standards bodies. IS auditing students have great difficulty in relating and applying theory, auditing techniques and tools to real world situations. While teaching IS audit has moved from a systems based to a risk based approach, paper based activities and role-plays have not proved sufficiently effective.

Real practice is difficult to organise, issues of confidentiality arise and it is not possible for each student to gain access to banks and other large corporations to interview senior staff, and access files and databases. The promise of interactive multimedia simulations is to provide a more effective link between the theory and actual practice.

A UNSW educational development grant was awarded to the authors (from the School of Information Systems and The Audio Visual Unit), to develop an interactive multimedia (CD-ROM) package. The package would be used for teaching computer assisted auditing techniques to undergraduate and graduate students. The program would provide a situated learning environment where students will learn how to audit and investigate fraud using a computer auditing program - Audit Command Language (ACL).

The package would enable the students to understand the theory behind auditing a client’s information system data bases, as well as providing hands on experience using specialised computer auditing tools. A fraud case will be developed using combinations of video, data, ACL and multimedia authoring software to enable the
student to see, for example, the fraud occur, to observe the effects of the fraud and to investigate the fraud using ACL.

2. **Project Objectives**

The project’s main purpose was two fold:

- to develop a multimedia program that will encourage active learning in how to audit an organisation ‘s computer systems using Audit Command Language (ACL). This multimedia package will enable students to understand the theories behind auditing and give practical experience by using ACL in a simulated environment to track down a fraud situation; and
- to establish a skilled interactive multimedia development and production team, competent in the design and authoring processes of CD ROM and with the appropriate hardware and software to facilitate the production of further multimedia teaching packages.

Individual project objectives include to:

- develop a prototype CD ROM multimedia package that will successfully allow second year auditing students and graduate IS audit students to learn to how to audit in a computerised environment and use the audit retrieval package, ACL;
- construct this package in an innovative and creative manner using the multimedia technologies of; video, graphics, animation and audio, so that the learning process will be engaging and appealing to the user;
- select the most appropriate educational philosophies and instructional design techniques in presenting the material to be learnt so the learning will be more enjoyable, more cost and time efficient and overall, more effective than the previous form of instruction;
- achieve a program that after extensive trailing and evaluation, will become a marketable product for other training institutions; and
- achieve these previous objectives within the allocated time and budget.

3. **Instructional Methodologies**

**Pedagogical Principles**

One of the issues addressed by the development team was to consider as part of the design phase a pedagogical underpinning to the development of the program and to relate this to the known capabilities of existing multimedia CDROM systems.

Developments in educational theory are leading to changes in educational practice that involve using Problem-Based Learning [Barrows 1986] and Cognitive Apprenticeship approaches [Collins, Brown & Newman 1989]. Important components of this approach include situated practice, where the learning activities occur in a context that approaches real use, and scaffolded practice, where initial learning is supported and that support is gradually removed. Multimedia simulations provide an effective way to provide such practice opportunities [Reiber 1992]. This project provides a scaffolded practice opportunity for the range of IS auditing tasks.

The approach taken by the team was to try and create a learning environment in a 'real world' setting that was learner centred. [Laurillard 1994] has emphasised the importance of considering how a particular educational technology is able to support teaching and learning. She feels that multimedia generally has the potential to support exploratory learning by students, harnessing the adaptive capability of the computer to the database capacity of multimedia.
During the development process, the team grappled with the learning objectives, the knowledge base and the known potential of the medium in order to arrive at a design that included a range of elements in the program - video, audio, stills, graphics, text, and an auditing computer software package (ACL) - to support the learning strategies. An important dimension involved trying to provide the highest level of interactivity within the scenario, bearing in mind the constraints of the technology and the budget available.

As [Sims 1994] points out a key part of the design of multimedia programs is the construction of effective interactive strategies, which he categorises into seven levels - ranging from passive interactivity found with 'page turning' programs to situate interactivity associated with virtual environments. This project provides an example of the way a multimedia development team has developed a case study within a simulated environment.

Additional requirements for effective education include that the instructional environment include reflection [Laurillard 1994] and that the learner be provided with an integrated environment including a variety of learning tools and be supported by a variety of interaction styles [Wills 1994]. Reflection on the process has been incorporated into the subject structure, and the simulation is supplemented with online references and the computer-based tool.

Learning Outcomes

The learning outcomes that will be achieved include better integration of theory, better linkage between auditing theory and practice, and increased ability to apply auditing techniques to the workplace.

Practical Outcomes

The multimedia simulation will:

• replace paper based activities with a real world simulation that provides an integrated approach;
• enable students to use problem based learning and receive immediate feedback;
• allow for variations in student abilities and provide an opportunity for students to build their skills in controlling their time and budget;
• provide an opportunity to work at their own pace, individually or in teams;
• provide remediation to students by downloading refresher notes and, through online tutoring, revision and help;
• allow students simulated 'access' to experts in their work environment to improve their interviewing and data collection skills;
• assist students in the review and evaluation of their work as they progress through the simulation by dropping down their work on disk to be reviewed at home;
• enable tutorials to be more effective; and
• provide for higher motivation, application and retention [see Lajoie & Lesgold 1989].

Integration into Total Learning Process

In order to integrate the package into the total learning process, the simulation will replace paper based activities in IS Auditing and Auditing subjects and complement lectures on the topics covered by the simulation. The simulation will also be supplemented with opportunities for reflection during follow up tutorials, and the content issues of the simulation will be assessed in the final exam for the subject.

4. How the Program Functions

The program is designed so the user is given the motivation of being a fraud squad 'audit detective'. The Fraud Squad have been approached by the bank's CEO who advises that OPAL Bank has lost substantial sums of money from somewhere in the bank's operations. A fraud is obviously going on, but where and by who is up to the user to discover. The Detective Inspector passes the case to you, a final year probationary detective, to solve.
The user is presented with a simulated banking environment and interface where various 'suspects' work. By entering rooms and asking the suspects (Bank employees - systems analysts, programmer, accountant, etc...) various questions, the user receives either video or audio responses from these people, some of which will be clues. The user then gathers additional relevant information from these people to assist in the investigation by searching records or information provided by the employees. In addition, relevant information will need to be gathered and investigated by reviewing system databases.

Two tools are used to assist in the investigation. 'The Note Pad' is a hand held pocket organiser which holds the questions that may be asked of suspects. 'The Lap Top' is a convenient simulated laptop computer that permits you to download system files and also enter any other relevant information. When the user has collected information and files, they can retreat to the library, a resource room, where this information is fed into the ACL program for audit review investigation. Part of this package involves helping the user come to terms with ACL so the library/resource room will also include instructions on how to operate ACL, as well as contain reference materials to previous frauds and audit knowledge [see Fig. 1] - the Knowledge Map.

The program has two distinct sections, the simulated office environment and an instructional section where the user searches for relevant knowledge to help with their learning and finds out how to use ACL. Once the data is collected, the user explores and tests it using ACL to discover any fraudulent activities. A test matrix is used to record the type of fraud, perpetrator, motive and financial dollar loss. The user may download results of their investigation as they go onto a floppy disk, including their audit working papers, and knowledge reviewed from the library/resource room. Users must also identify the weaknesses in the system which may have encouraged the fraud to take place, and develop a report to present to their superior. When the user believes that the case is solved, the testing matrix is submitted by video conference with the Detective Inspector, who will advise the user as to the success or otherwise of their fraud audit endeavours.

5. Design & Development (System and Knowledge)

Prior to the system design commencing, a search of the literature, the World Wide Web, previous teaching development grants, and discussions with practitioners, including leading members among the big six accounting firms, indicate that this is the first program of its kind in the IS auditing area.

Project Plan

A University of New South Wales (UNSW) development grant was received to evaluate the feasibility of this project and build a prototype. Phase one of the development includes one fraud scenario with selectable multiple results. The plan for a future phase is to develop additional scenarios and concurrently improve on the instructional design.

Resources

The allocated project budget of $50,000 was complemented by resources from the Audio Visual Unit in the form of staff time (graphic artists, video producers and technicians); video and audio facilities; additional Computer Hardware and Software; and workspace. The hardware consisted of Apple Power PC’s 7100/8100, Video Vision Studio Capture board, a Pentium Multimedia PC, Scanners and a CD-ROM burner - Pinnacle Micro. The package was developed on a Mac, however the delivery environment is PC based. Software used in the project included Authoring software - Authorware 3.0 Director 4.0; Video software - Adobe Premiere, Aldus After Effects, Movie Player, Quicktime 2; Graphics software - Adobe Photoshop, Debabelizer, Adobe Illustrator, Strata Studio Pro; Sound Editing - Sound Edit 16 - Sound Blaster 16; CD Burning - CD Toast Pro V 2.5; and Project management - Microsoft Project.
Project Team

The project design and development team consisted of the following types of personnel: Project Manager; Designer/Content Expert; Instructional Designer; Graphic Artists; Video Producer; Photographer; MM Production consultant; Authorware/Director Programmer; Authoring Consultants; External Auditors (consultants); Review team (3).

The most difficult parts of the project were project coordination, especially coordinating the many part time personnel so all resources are used effectively. Also integrating video and sound proved difficult.

System Design Components

As a guide to the look and feel of the package, Figures 2-5 provide a glimpse of the graphics and navigation features. [Fig. 2] is the Bank entry screen, where the guide provides help and assistance, as well as a guided tour around the package prior to commencing the audit. Once inside the bank the lobby foyer staff directory [Fig. 3] provides the main link to moving between offices. A typical office (Alice Smart's) is shown in [Fig. 4] which is a combined drawn graphic with photos for the window shots and a still from the video to hold until the person, in this case Alice, is questioned. The Lap Top on the floor of the office may be accessed at any time.

Navigation is handled in two ways. First, by an intuitive mode (clicking on doors to go out etc.), and second, by a drop down menu selection bar for the system minded users. This is shown in [Fig. 5] and activated by using a mouse rollon/rolloff on the guard's head icon at the top left of the office. When an office is entered a short video introduction is played. To ask questions of the person, you click on the person and The Note Pad is activated, as shown to the left of [Fig. 5]. The Note Pad provides the questions that are permissible to ask of each person. Questions may be scrolled on the Note Pad and may be asked in any order. When asked, the question number is highlighted to indicate that you have asked this question previously. When a question is selected, either a video or audio segment is played. The video was shot on a blue screen and chromo-keyed later onto the backgrounds. Questions and answers are automatically transferred to The Lap Top so the use can work through them later. These may be downloaded to the user's disk.

The Lap Top works as a GUI/Windows type look alike with icons for all options/functions. These functions include: budgets; video conferencing to external auditor and Fraud Squad; audit work papers; audit tools - ACL and tutorial; approvals and passwords; reference information - auditing and computing; and fraud reporting.

Scoring in the simulation uses the concept of time taken (against user set budgets), items of information gained and questions asked. This is represented as status bars which may be toggled on and off. Solving the case asking minimal questions and in a shorter period of time would help to highlight a more efficient problem solving approach.

6. Monitoring and Evaluation of the Product

During 1996 the simulation will be finalised and trialed with IS audit students at UNSW. Trials were also held during development with selected IS audit students and practising auditors to provide formative feedback. In 1996, the project will be used in the IS audit subject and the IS audit component of the auditing subject, both to provide further formative feedback on the system and to evaluate the educational effectiveness. An evaluation expert from the Professional Development Centre at UNSW will assist with these trials and their evaluation. Trials will also be held with practising auditors from the firm of Coopers & Lybrand (Sydney office).

This evaluation will occur at various stages of the development, including initial design, story board walkthroughs, knowledge maps, online tutorial design, interaction design, useability design, prototype development, case study design and review, major trialing and final evaluation. The outcomes will provide the
basis for further modifications and trialing before the final version is completed. After completion of the project further evaluation of the program's teaching effectiveness will be carried out.

7. Benefits

One of the main benefits of the program is that it can be used as a training tool for auditing students and less experienced IS auditors as well as for more experienced auditors who are not skilled in using computer audit software. Other benefits include:

• an enticing and interactive learning environment;
• the ability for the learner to learn at their own pace;
• experiential learning;
• feedback throughout the simulation;
• ability for the learner to draw on learning resources when they run into trouble or don't know what to do next;
• ability to use audit software to assist in the fraud investigation;
• the opportunity for the learner to set their own budget for the investigation;
• the opportunity to interact with staff in an organisation within the simulation; and
• the ability to interact with experts.

Skills auditors acquire include:

• management planning and awareness of budgeting skills;
• appropriate interviewing techniques;
• ability to use laptop to collect data, organise audit information and prepare an audit report;
• ability to critically analyse data from various sources (ie interviews, reports, computer data);
• ability to draw conclusions as to: perpetrators of the fraud, motivation or reason for the fraud; how the fraud was perpetrated; the impact and extent of the fraud; and recommendations for improvements to the system of internal controls and security of the system under review.

Deliverables include:

• management plan;
• budget for audit;
• identification of fraud type, dollar loss, perpetrator, and motive; and
• a weaknesses and recommendations report.

8. Future

The simulation will be available in a digital media form to other universities and information about it will be available on the UNSW Web page. Further case studies will be added as well as creative ways of presenting information systems audit knowledge. Further research papers on the project outcomes and the processes involved will be produced.

The success of this project was determined by the following major factors:

• the dedication of the project team members;
• the ability of the project manager to plan, guide, instruct, and motivate the team according to strict time and financial constraints; and
• the program appealing to the user and being educationally more effective in teaching the required skills than the previous form of instruction.

This project has not only provided a very useful package but the process undergone has been a valuable learning exercise. This has enabled the Audio Visual Unit at the university to understand the process, ramifications, technical and resource requirements necessary to develop these types of multimedia programs.
9. References


Figure 1: The Knowledge Map

Note: The colours in the following figures do not reflect the true originals as a custom palette is supplied with the CD-Rom product.
Figure 2: Bank Exterior

Figure 3: Staff Directory (Main Menu)

Figure 4: A Typical Office (Alice Smart’s Room)

Figure 5: CEO’s Office (Showing Note Pad and Menu Icon Bar)
Multimedia-based Case Studies in Education

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Abstract: This contribution describes experiences with a multimedia case study used at the Department of Information Systems for training students in data processing for business purposes. The report includes a description of how the case study was integrated as a didactic element in a university course, with special emphasis being given to theoretical aspects of presentation and learning. Additionally, a description of the case study and its development rounds off the article. The experiences were gained within the framework of an explorational, empirical study whose results are presented at the end of this paper and form the basis of suggestions for how the case study could be developed further.

1 Initial Situation
At the Department of Information Systems of the University of Innsbruck, a one-year project was conducted to develop a multimedia case study. By April 1995 the development of the case study had progressed to such a degree that it could be tested in practice in the Systems Planning II course. This report describes the implementation of the case study according to a method presented at the ED-MEDIA 1995 [JaKaWa, 1995] as well as first practical experiences regarding the use of the case study.

The students' instruction is expected to include "more theory" and "less theory" as well as "more practical experience" and "less practical experience" [Roithmayr, 1994]. More theory means that graduates should be able to apply general theories in their approach to problems. Less theory refers to the fact that specific theories are often viewed as unnecessary because they are impractical. While some theory is necessary, specific aspects of theory can be eliminated because they are not applicable. The same is true of practical experience, which cannot be learned in the classroom. Practical experience means that students must be trained how to apply theoretical knowledge and how to recognise situations in which theoretical knowledge is required. There is a need for didactic methods which give students a feeling of confidence in the decisions and judgements they make when dealing with practical problems.

2 The Learning Process in Information Engineering
At the Department of Information Systems information engineering is taught in the "Systems Planning" course. The aim of this course is to reinforce, apply, and enhance students' prior knowledge acquired in lectures in this field. The learning process is significantly influenced by two filters:

- presentation of information (didactic preparation)
- learning of information (dimension of learning).

Figure 1 shows how the learning process is influenced by the presentation and reception of information. The starting point is the intended teaching goal. The lecturer (teachware) must present information in such a way that this goal can be achieved. Additionally, the method of how information is received and perceived has to be taken into consideration. The latter has a human focus (students) and is described theoretically primarily by the theory of learning, i.e. the dimensions of learning.

2.1 Didactic Presentation of Information for Information Engineering
Information engineering focuses on the design, development, implementation, maintenance, and utilisation of information systems. [Mertens, 1992] The central aspect of this system is the transfer of procedural knowledge. Lecturers are faced with the following problems:

- On-the-job training is almost impossible, especially considering the large number of students involved.
- Demonstrating the development, implementation, and the utilisation of information systems would require far more time than is available in regular courses.
- Modern information and communications systems (ICS's) are so complex that one can hardly isolate individual aspects and work out solutions which can be presented in a classroom situation.
- The application and use of ICS's can be demonstrated relatively easily. It is, however, extremely difficult to simulate the design and implementation stages of information and communications systems.

The use of "classical" case studies was able to improve the situation at least from a didactic point of view. From an educational point of view, using case studies is effective because it encourages learning by requiring students to find rational solutions to "real" problems. Because the case study also involves constant feedback between
students and teachers, it fulfils the requirements of learning theory. As for motivation psychology, the case study puts students in a situation which motivates them to make an effort.

We realised early on that sophisticated studies pose a real challenge, namely how to represent reality. If case information for solving a problem is supplied in a structured form, the task of collecting and structuring information (system analysis) has already been accomplished. If information is supplied in an unstructured form, even minor tasks involve a great deal of information on paper - something that neither motivates the students nor presents the real situation satisfactorily.

Facing these problems, we found multimedia-based case studies to be a suitable tool for providing a mix of structured and unstructured information to the students. In order to prove this, multimedia has to be evaluated under the aspects of learning theory.

2.2 Dimensions of Learning - Multimedia Support

Structured explanation models of the learning process are supplied by psychology. Parallel to purely psychological theories of learning, cognitive science and cognitive engineering as cybernetics have been developed. Significant fields in these areas include cognitive psychology, neuro-science, artificial intelligence, linguistics, and epistemology. [Varela, 1993] As a result of contemporary research in learning theory, five dimensions of learning can be identified. These five dimensions can be employed to evaluate the use of multimedia.[Schneider, 1994].

- Basic metaphors: representation versus construction
- Systems level: single-loop and double-loop learning, as well as learning how to learn
- Consciousness: implicit and explicit learning
- Intensity: ranging from cognitive learning to internalised knowledge
- Brain activity: where, when, and how does learning take place

2.2.1 Basic Metaphors

Learning as representation process sees the (behaviouristic) learner as an empty sheet of paper that needs to be filled. Learning as construction process sees the (cognitive) learner as a candle that can be lit. [Baumgartner, 1993].

In the multimedia case study, the representation versus construction dichotomy can be reduced to the navigation possibilities of guided navigation versus open consultation. Guided navigation forces the user to follow a prescribed path of learning and corresponds to the model of behaviouristic learning. Open consultation allows free navigation in the information space. Pure, non-linear navigation is, however, problematic, [ReOug, 1995] and in most cases a compromise between open consultation and guided navigation is employed. Variations that confront the learner with constructive tasks are very promising. Every multimedia case study should be a combination of open consultation and guided navigation. Open consultation is necessary for providing a field of investigation which models reality as closely as possible. On the other hand, a certain amount of navigation is necessary to ensure that the case study is used to achieve didactic and content gaols.

2.2.2 System Level

Argyris/Schoen [ArgScho, 1978] differentiate between single-loop learning, double-loop learning, and learning how to learn. Single-loop learning relates new material to already existing knowledge. In the course of double-loop learning, the framework of basic parameters and background assumptions is changed. The third step,
learning how to learn, represents the ability to use self-observation in order to develop a flexible model how and under which circumstances one has to switch from single-loop to double-loop learning.

The aim of the multimedia case study is single-loop learning. Because of the photo-realistic and audio-visual techniques employed, content material appears highly credible in single-loop learning. It is difficult to support the other learning levels technologically. The simulation approach could be used to look at the content from different perspectives and under different assumptions, but this is possible only if alternatives are clearly defined.

2.2.3 Consciousness

In this regard, systematic and conscious learning is contrasted by implicit learning. In principle, multimedia techniques support both forms. Concrete examples in terms of the multimedia case study include responsible management of resources (motivated by the point system described below) and - on the basic level - the use of multimedia technology as such.

2.2.4 Intensity of Learning

Schneider [Schneider, 1994] differentiates between three levels of learning intensity:

- lexical knowledge
- applicable knowledge
- knowledge of problem solutions

Multimedia techniques primarily support the learning of lexical information. If the virtual environment provides sufficient possibilities of applying knowledge, learning in virtual realities can reach the application level. The described case study offers the necessary virtual environment. Virtual realities can be divided into Level 1 (passive users), Level 2 (active, navigating users), and Level 3 (interactive, design-oriented users). [AukBla, 1994] The case study described here makes it possible to cover Level 1 and Level 2.

2.2.5 Brain Activity

Neuro-science investigates where (in the left or right half of the brain), when (activation state of the brain), and how (according to which basic patterns) learning takes place. [Vester, 1980] The use of multimedia techniques supports primarily the "how" aspect through different input channels. Verster's classification of the basic patterns of thinking into four channels (intellectual, visual, haptic, auditive) [Vester, 1980] can be supported well by presenting information interactively and audio-visually. Through associative pictures and sounds, anchor points for improved transfer from ultra-short-term memory into short-term memory (and thus into long-term memory) can be created. Animations generate analogies to prior knowledge and are therefore also able to illustrate complex interrelationships. [Rieber, 1994].

3 The Airline: An Example of a Multimedia Case Study

The following example of a multimedia case study involving an airline illustrates the application of the action model described above. The educational goal of data processing for business purposes is to provide students with theoretical and practical knowledge especially in the fields of information management, methods of system planning, software engineering and project management. The didactic macrodesign defines as teaching goals the transfer of practical knowledge within the framework of teaching situations in the fields of information management and methods of systems planning. The following formulations of questions and tasks are to be used in handling the case study and were developed within the framework of the microdesign.

- Organisation analysis: The students describe and analyse the organisation of an enterprise with the help of various methods such as SADT, object-oriented analysis, HIPO, etc.
- Technology analysis: The students analyse and evaluate the technology used (hardware and software). In doing so, they must take into consideration the current state of the technology and the market situation.
- Assessment of the physical model: Students identify the weak spots of the organisation and technology and prepare suggestions for how they can be eliminated.
- Development strategy: Students develop a strategy and global guidelines, for example with regard to decentralisation, standard software, communications systems, etc.
- Organisation of information management: Students suggest forms of organisation able to accomplish the task of information management within an enterprise.
- System architecture: Students develop the infrastructure of hardware and software technology capable of meeting the enterprise's future needs in terms of information and communications systems.
- Project portfolio: Students should extrapolate and assess projects on the basis of the current model.
Since the number of tasks presented far exceeds the time limitations of the course and because some tasks are continuations of previous ones, additional information is available to aid students in completing the tasks. This information is based on the case study and allows students, for example, to formulate a development strategy without first having to carry out a detailed analysis. The information needed is already available in the form of preliminary results.

3.1 The Concepts of Roles

The concept of roles in the case study basically consists of a situation in which the student works with the enterprise as an external consultant and is assigned a problem-related task. The role of the course trainer is limited to that of the employer, but he/she must also provide preliminary results as needed. As an additional dramatic element we introduced costs of information. In the course of the case study, points are added to the student's accounts for each piece of information the student uses (with the exception of entries in the glossary). The number of points added depends on the source of information and the importance of the information in the task-solving process.

3.2 Navigation Concept - User Interface

The case study presented here works on the principle of open consultation, which means that the student always has access to all the information available. The organigram of the enterprise serves as a framework and orientation help. Since the analysis of the organisation is a primary aspect of all questions and tasks the student is confronted with, we designed the user interface around the following aspects of the airline:

- Structure: The structural aspects of the organisation influence the information flow as well as decision-making process within the organisation and the activities used to monitor external developments, e.g. market research.
- Business processes: The process aspect covers all activities undertaken by the organisation in order to fulfil customer requirements. Processes can be divided into primary and secondary processes. The distinction is made by answering the question of whether a process has direct impact on the product (e.g. flight planning) or aims at product support (e.g. human resource management, finance).
- Information: All activities within the organisation have an information aspect. Therefore the information (data) processed in the organisation has to be taken into consideration.
- Information processing equipment: Although technical questions have no direct influence on the organisation, information management and infrastructure design have to deal with information processing equipment.
- Information about the airline business: Finally, the business field of the organisation influences organisational decisions, such as decentralisation, required flexibility, etc.

In order to cover these aspects, the following design was chosen. The organisational structure is represented by a structural chart and the student can go to any of the departments and access the information available there. Each department offers him/her three possible sources of information:

- Interview: A list of predefined questions can be asked at each position. The answers (text, video, or audio information) include descriptions of all relevant business processes.
- Files: Any documents, files, forms, etc. found at a certain position are stored in filing cabinets (pictures, electronic documents) and can be viewed on the computer screen. The documents cover the information aspect down to the attribute level.
- Information and communications technology: Each position is equipped with information processing tools, such as a PC, fax, and access to application systems. These tools represent a significant source of information for the student and are presented as a separate block of information. Both case-specific information and technical aspects are taken into account.

Every effort was made to make the task as realistic as possible by distributing the information among the various positions of the organigram. The multimedia adaptation of information supports this effort. Information relevant for the airline industry can be found in a glossary containing generally valid facts and technical jargon relevant to the enterprise. The glossary is represented in hypertext format and can be accessed at any time.

3.3 The Creation of the Case Study

3.3.1 Content Analysis

In the case discussed here, the primary information is the organisational structure of the enterprise. Additionally, the student has access to technical information and statements by the management concerning the leadership and
development of the enterprise. The company's value-added chain [KaWal, 1992] was used as a means of defining the content analysis. Market observations, risk management, etc. are ignored given the didactic design. Several processes were simplified for the case study model. Content analysis in the course of the production of the case study was achieved by means of structured analyses and interviews; the presentation of the case study model was achieved by means of a chain of processes.

3.3.2 Storyboard
The incorporation of the chain of processes made it necessary to structure the processes in small information chunks. Special care was taken so that no case information was lost in the process and that the links between the information chunks were preserved and understandable for the student. In addition, hints at other chains of processes had to be incorporated into the chain of processes, thereby providing a way for the student to conduct a targeted search for information. The information chunks were arranged according to their content. The most notable fact which came to light here was that the information chunks can be identified by the chain of processes to which they belong and by the position to which this information is assigned. When assigning chunks to a chain of processes, the chunks can be checked for completeness, and assigning them to a position facilitates media production significantly.

3.3.3 Implementation
MS-Windows and Toolbook 1.53 were used for the implementation of the case study. Videos, audio tapes, and pictures were produced independently. The evaluation of the various development levels revealed that authoring tools do not provide a sufficient number of interfaces to data bases to administer the students' points accounts. They also failed to provide sufficient support for the separation of application and multimedia data and could be used only by programming specialists. Toolbook was therefore ultimately chosen (open interfaces and programming options).

4 The Use of the Airline Case in the "Systems Planning" Course
In the spring of 1995, the case study was used in the "Systems Planning II" course. Twelve groups of three students were expected to use the case study. The task was to produce a systems analysis of the enterprise described in the case study. After completion of their tasks centred around the multimedia case study, students filled out an electronic questionnaire. Table 1 illustrates the most important results of the evaluation:

<table>
<thead>
<tr>
<th>Overall impression</th>
<th>4.84</th>
<th>6 = excellent, 1 = insufficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helps learning</td>
<td>3.85</td>
<td>6 = helps a lot, 1 = does not help</td>
</tr>
<tr>
<td>Clearly structured</td>
<td>4.64</td>
<td>6 = clear, 1 = unclear</td>
</tr>
<tr>
<td>Degree of difficulty</td>
<td>4.09</td>
<td>6 = difficult, 1 = simple</td>
</tr>
<tr>
<td>Sufficient prior knowledge</td>
<td>4.42</td>
<td>6 = enough prior knowledge, 1 = not enough</td>
</tr>
<tr>
<td>Sufficient information for finding a solution</td>
<td>4.00</td>
<td>6 = all information available, 1 = not enough</td>
</tr>
<tr>
<td>Navigation</td>
<td>3.12</td>
<td>6 = no problem, 1 = very difficult</td>
</tr>
<tr>
<td>Comprehensibility</td>
<td>3.88</td>
<td>6 = very comprehensible, 1 = incomprehensible</td>
</tr>
</tbody>
</table>

Table 1. Evaluation of the Multimedia Case Study
The question if they would prefer a traditional (printed) case study, was answered negatively by 28 students, affirmatively by 5 students. Those five students did not, however, have any prior experience with cases studies (in general, of all students 15 had experienced case studies and 18 had not). In addition to quantitative evaluations, students were able to make qualitative statements regarding this form of case study. In general, this kind of case study was received extremely well by the students. This form of education modelled after practical conditions was particularly regarded as positive. The majority of all students appreciated the audio-visual method of presenting information and learning within a game situation. Reasons given for the good overall impression and practical relevance included the practical approach and the challenge to independently filter information. Criticism was voiced primarily with regard to the technical equipment available (bad screen resolution of the videos, too slow) and the optical design (layout, colors). The students' ability to concentrate and find relevant information were obviously taxed highly, and it was difficult to maintain an overview of the plethora of information. Another criticised aspect concerned the information modules free of redundancies which really offer information only at one place in the enterprise. The following improvement possibilities constitute the concrete result of the evaluation.

- The information modules may not appear totally free of redundancies. Similar information has to be offered at different places in the case study.
• To a certain degree, data should be contradictory - which is realistic - in order to simulate decision making processes.
• Technical improvements regarding the size and quality of images are necessary. The layout has to be improved, etc.

5 Summary
The time needed for creating this multimedia case study amounted to approximately 1.5 man years, and was thus significantly more labour-intensive than traditional case studies (with increased experience, it should be possible to reduce this effort). The clear advantage is the broader field of application of the multimedia case study - more teaching goals can be achieved. Case studies can replace on-the-job training only to a certain degree. However, the multiple presentation possibilities of multimedia technology approximate reality better and are thus able to improve the quality of education. The case study presented in this report has a relatively static structure. Further developments in the direction of dynamic structures and processes could increase the value of multimedia case studies significantly.

6 References:
A Classroom-Based Multimedia Teaching System: SHARE

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Abstract: The rapid developments in multimedia technology offer many new possibilities for improving and re-organising the teaching-learning process. But how to make a widespread use of this technology in the practical instructional process, particularly in a classroom context, is still an unsolved problem. Knowledge of the educational possibilities of multimedia is a different issue than the development and actual use of educational multimedia applications. The necessity of sharing (limited) technical educational resources is a considerable issue in this respect for lesser developed countries. In this paper we discuss resource sharing in relation with the development of a classroom-based multimedia teaching environment - the SHARE system. This system is in use in several large cities in China (Shanghai, Beijing, Nanjing) for classroom-based teaching and learning. The discussion focusses on the design ideas and the communication functions of SHARE.

1. Introduction

How to establish a multimedial environment that can be effectively used in current school organization, particularly in classroom-based teaching and learning circumstances, is still an unsolved problem and an interesting topic. Although most Western countries strongly stress individual learning and personalised instruction, the fact is that most schools in Asian or even in Western countries today are still keeping to a classroom-based or group-based teaching style.

The research on multimedial learning environments for classroom use can be carried out from different viewpoints; for example: what media are more suitable to be used in a classroom context? Will multimedia technologies have a stabilizing impact on our current educational system? In this paper, we discuss the design and architecture of the SHARE system, with emphasis on its communication functions. The application and educational experiments with SHARE takes place in different instructional settings in China, mainly in some of the large cities: Shanghai, Beijing, Nanjing.

1.1 Design ideas stemming from the language laboratory

Before discussing the design and architecture of the SHARE system, it is necessary to offer a brief description of our previous system CBTL (Classroom-Based Teaching and Learning) system [Zhang and De Diana 1990, 1991]. The CBTL system was developed five years ago and is still widely used in different schools in China today. Basically, the CBTL system is a computer-based system, connected with some traditional media and mainly suited for use in classroom contexts. The design ideas of CBTL were primarily driven by language laboratory technologies, which can be viewed as a kind of educational system for classroom use and is primarily used for (foreign) language teaching. It is popular in some oriental countries, such as China, Japan, and South Korea. Most language laboratories are composed of a teacher console, some audio facilities, and a considerable number of student booths. Provisions are available for a whole class of students to listen to a master recording, to the voice of the teacher, or to other audio sources.
The teacher, generally, can listen to any one student and can verbally communicate directly with any one or with a group of students.

Two types of language laboratory systems are in common use - the audio active comparative system (named AAC) and the audio active system (named AA).

Based upon the architecture and educational functions of language laboratories, we have considered the possibility to connect a computer and other educational facilities or media, including visual facilities, into such a system to expand its educational function in classroom context. This has lead us to develop a classroom-based teaching and learning system. There was yet another reason for us to develop this system. We would like to make the use of computer resources in education more effective and especially computer resource sharing by a classroom. Classroom-based resource sharing is in particular meaningful for lesser developed countries, given the general shortage of funds and media and computer equipment. During the past few years, the CBTL system has been well received by Chinese schools and over several hundred systems are running in different educational settings of which over 50 percent in secondary schools.

1.2 System functions

In respect to functionality, the presently available functions of the CBTL system can basically be divided into two parts: teaching/learning, and testing. In the teaching/learning process, some of the main functions are:

1. by means of the menu available on the computer screen, the teacher can select an audio or video channel, or courseware, or an audio/visual mixed course to send to the whole class of students;
2. the teacher, if necessary, can verbally communicate with any one student or a group of students;
3. students, when necessary during the course, can personally call the teacher;
4. grouping of students for verbal discussion, in pairs (two students) or groups (four or eight students), is possible, but the discussion is limited to the same group-bus which implies that the likely set of communication targets is fixed.

For the testing part, the available functions are:

1. to build an item bank for testing purposes;
2. testing, which means sequentially presenting test questions on the student's screen and gathering student's responses;
3. data processing and analyzing.

1.3 Limitations

Although the CBTL system has been received well by Chinese schools during the past few years, it has shown some weaknesses as a consequence of the rapid developments of educational technology, and some limitations have also been noted by users (teachers) resulting from practical application in different educational subject areas such as language learning and mathematics. We can sum up the following limitations:

1. system architecture presently it is impossible for a student to make a free choice to communicate with other students in the class;
2. role of the teacher: the role of the teacher is mainly restricted to being an operator and a deliverer of messages which limits the full employment of teaching strategies;
3. media support: the CBTL system design only supports some rather traditional audio/visual equipment, such as a sequential tape recorder, a video recorder, and a video camera. Recent products such as CD-ROM, CD-I (compact-disc interactive), DVI (digital video interactive), and digital audio products can not be directly used;
4. software environment: the CBTL system was based on Apple II and IBM-PC XT computers; and is as a consequence limited and unflexible.
5. communication patterns: only three fixed communication patterns are available.

2. The SHARE system
Given these limitations, it was necessary to consider the design of a new system for classroom use. In this system, named SHARE, five system aspects are to be improved: hardware architecture, multimedia facilities, role of the teacher, software environment, and communication patterns. Figure 1 shows the differences in these five aspects between the CBTL and the SHARE systems.

2.1 The conceptual Model

Based on these five aspects, the design of SHARE aims at improving the quality of educational messages, particularly enhancing the capacity of communication between the teacher, learners, and media in the classroom. The conceptual model of SHARE is shown in Figure 2.

The teacher, will in SHARE be viewed as an information resource and information manager, and not only as an operator for the computer and the media facilities. This implies that the system should be able to stimulate teachers’ initiatives as much as possible. As an information resource, the teacher should be able to express freely and smoothly his ideas, opinions, and knowledge, in different forms to students when he/she is using the SHARE system. This characteristic can be obtained through a well organized hardware and software environment and multimedia facilities. In the aspect of resource manager, the system should facilitate the teacher to easily arrange and adjust the contents of the course, materials, media facilities, classroom grouping arrangements, and the teaching strategy. In SHARE, the hardware and software environments constitute the main organisational body that involves all functions with respect to the physical
hardware link, instructional message sources, communication control, as well as the authoring environment. The terminal environment provides students with a good condition for learning activities. Each terminal is equipped with a video display for showing visual messages from the computer or video facilities, a microphone and an earphone for verbally communicating with the teacher or with other terminals, and a specific keyboard with liquid crystal display for exchanging information with the computer or teacher.

2.2. Communication architecture of SHARE

The SHARE system design focusses on the communication principle and intends to enhance the communication capacity between teacher and students in classroom. [Romiszowski 1992] has pointed out: "The process of instruction itself, is therefore a two-way communication process. ... The concept of communication is closely linked to the concept of learning" (pp. 4-6). So the communication principle is suitable to describe the specifications and functions of SHARE. "The communication architecture is to specify component interactions, and ultimately the details of the interface among interoperating components" (p. 6) [Nutt 1992]. A layered communication architecture for SHARE is shown in figure 3.

Like most computer communication systems, the architecture of SHARE consists of seven layers situated from low to high. In general, the lower layers provide services to the higher layers. Due to size constraints we can not discuss the specifications of all layers in detail and only some of the relationships between the layers can be mentioned.

3. Some of the layers of SHARE’s communication architecture

3.1 Communication Pattern Management (CPM)

In the SHARE system, there are five main communication patterns named a Pair, Four persons, Eight persons, Sixteen persons, and Whole class. It is possible for each pattern to exist in two modes: fixed and flexible. In the fixed mode, the students are grouped according to the students' seat sequence, in which the communication targets are always fixed and it might happen that some students can not communicate when nearby students are absent from the course. In the flexible mode, the communication target can be selected within the whole classroom range, which implies that different combinations of students' seat are available.
During each communication process, the teacher can join or monitor any pair or group at any time. Examples of communication patterns in the two modes are shown in figure 4.

![Fixed mode](image1)

![Flexible mode](image2)

Figure 4. Examples of communication patterns

In the example of the fixed mode, the students can only communicate with nearby students. In the flexible mode, the students can communicate with any one in the class range.

3.2 Learning resources (LR)

This layer deals with the representation and delivery of teaching content material and offers detailed information to the three lower layers. The information usually involves teaching content materials, sequence and time, message source selection, communication pattern (usually in whole class-teaching style), message channel selection, and enable or disable calling.

3.3 Application Layer (AP)

This layer involves subject knowledge that is to be conveyed to students, which contains the course architecture and the subject contents. The course architecture describes the static structure of a course. It represents the top-level organization of the subject knowledge. A variety of formalisms for the description of course architecture have been worked out, such as a tree expression for course architecture, which is used in SHARE. Subject content can be perceived as a collection or a multimedial database of instructional materials or messages [De Diana, Verhagen, and Heeren] (in press).

3.4 Authoring Environment layer (AE)

The authoring environment supports and facilitates the teacher to develop course materials for the SHARE system. The authoring environment is flexible and offers considerable freedom to its user (author or teacher). A flexible authoring system [Zhu and De Diana 1992, 1993] means an integration of authoring mode and expertise, applicability, cultural interface (linguistic difference, such as an ideographical language (Chinese), and phonetic languages (English)), domain knowledge representation, courseware organisation and management, and instructional strategies [Zhang and Collis 1995]. This layer includes a teacher interface which supports the teacher to fulfil tasks such as: organize or reorganize courses, media selection and management, regulation of the instructional process, instruction and communication management, and the acquisition of analytic reports from the system.
4. Conclusions

The SHARE system, stemming from the tradition of the language laboratory, can offer both cost effective resources sharing, which is a valuable asset for lesser developed countries and an interesting flexibility of communication patterns if compared with the older lines of language laboratory systems. As the precursor of SHARE, the CBTL system has shown to be readily applicable in secondary and higher education, it may be expected that SHARE can serve the same target audiences too. The layered communication architecture of SHARE allows for considerable flexibility in product architecture - and thus for a range of educational applications to be run within the setting of this 'classroom-based' system.

References


Scriptable Applications: Implementing Open Architectures in Learning Technology

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Abstract: The architecture underlying most educational technology prevents substantial extension, customization, or integration by those outside the development group. In contrast, "open" architectures can enable curriculum authors, teachers, and students to enrich the software. When successful, such open architectures can ignite grass roots movements which produce vast libraries of interesting, meaningful, and accessible activities. The power of open architecture can be seen with Hypercard and the World-Wide Web. In contrast, more "closed" architectures rarely excite the front ranks of education.

In this article, we report a relatively easy means for implementing open architectures in learning technology. Our strategy builds on the Open Scripting Architecture available in the Macintosh System 7. We have built a demonstration mathematics microworld that accomplishes three often-contradictory goals: (a) providing a highly-tuned direct manipulation interface (b) dynamically linking multiple representations and (c) supporting user programmability.

Software architecture has a strong effect on the capabilities of educational media. Here are some scenarios that illustrate the educational problems that arise because closed architectures do not support integrating, extending or customizing software:

1. A teacher would like students to compare simulated data from a model to empirical data from a probe. The teacher has both modelling and data collection software. Unfortunately, these packages have different graph formats and no way to easily send data from one to the other.

2. A teacher wants students to explore the effect of transforming a velocity graph upon the final position: What happens if you invert the time order of the graph? Or multiple the velocity at every point by 2? Unfortunately, it is nearly impossible to perform these transformations accurately by direct manipulation, and the developers did not anticipate the need for a "Transform" menu.

3. A teacher would like students to e-mail her sample graphs of their work. Unfortunately, it takes 20 steps to attach the graph file to an e-mail message and send it, and students can't remember how to do it. A custom command to "mail this graph" would make things so much easier.

Our open architecture software can easily overcome each of these problems, and in addition can:
- record student actions in an readable and executable language
- allow teachers to create custom tool bars for particular activities
- combine our microworld with curriculum authored in Hypercard, or delivered via HTML text on the World Wide Web.
There is a second, less obvious benefit to using a well designed, open architecture: it lowers the cost of software
development and user training. An open architecture allows developers to design systems that are made up of
many small functional modules interconnected by a common software interface. A developer can focus on
developing a single functional module and rely on well defined software connections to other modules that
perform related tasks. In example 1 above, the data probe module developer could focus on noise reduction and
other tasks related to data collection, while the simulation developer can focus on graphs and animation. Neither
developer has to develop the communications software; which can be supplied by a third party.

An open architecture can also, almost paradoxically, allow users access to a wider range of functionality in an
environment that is easier to use. World Wide Web browsers provide a good example of how an open system
can accommodate increasingly sophisticated capability within a single user environment. Users can access and
download text, graphics, audio, video and make interactive connections to other computers all through a single,
easy to use interface. The rapid explosion of Web capabilities is, in part, attributable to its open architecture and
widely accepted standards: interface standards simplify the user's task; open architecture and software standards
allow the developer to focus on her specific module with the confidence that she can connect to other software
modules to supply useful related capabilities.

The SimCalc Mission: Calculus Learning For All

The mission of the SimCalc project is to enable all children to learn the mathematics of change beginning in the
eyear grades. This mathematics is conventionally sequestered in elite calculus courses after a long series of
algebraic prerequisites, which denies access to critically important ideas of rate, accumulation, approximation,
limit, mean value, etc. Our NSF-funded projects aims to teach these essential ideas to mainstream children, as
one strand of a restructured K-12 mathematics curriculum. [Kaput, 1995].

Simulations and dynamic graphics can enable children to learn difficult concepts at an early age. For example,
White [White 1993] successfully taught conceptual physics to middle school students using the ThinkerTools
simulation, and these students surpassed their high school peers. SimCalc MathWorlds provides a variety of
schematic and realistic animated worlds in which actors move according to graphs. These graphs can be directly
edited with the mouse, and during edits they exhibit dynamic links that reveal the relationship between a quantity
and its derivative or integral. Games and challenges involving dynamic graphs in the animated worlds engage
students in learning central ideas in calculus and set the stage for other mathematics of change, e.g., dynamical
systems.

The sequence we have developed to teach the Mean Value Theorem (MVT) illustrates the SimCalc approach,
and introduces our MathWorlds software. In each activity, we cycle through three stages: warm-up, construction
and application [Lesh, Amit, & Schorr, in press]. In the warm-up for this activity, students build variable
velocity motions with constant velocity rectangles. Then students construct the constant function asserted by the
MVT using these rectangles. Finally, the students apply rectangular approximation to integrate the area under a
curve.

The warm up activity involves flying a UFO to pick up space rocks and drop them in a crusher. The UFO moves
g according to a sequence of two different constant velocities, which the students can adjust using the mouse. The
UFO's tractor beam stays on for the duration of its second velocity, enabling it to pick up and drop a rock. By
playing this game, students experience the relationships among rate of motion, distance, and time in constant
velocity graphs.

In the construction activity, students set the constant velocity of a walking man so that he arrives at the same
final location at the same time as a flying woman. She flies with constant acceleration. Solving this challenge is
tantamount to finding the mean value of the changing graph; students learn that, for a given time interval, they
can find a constant velocity that achieves the same final distance as any constantly accelerating motion.

In the application activity, a mother and baby duck swim in a pond. The mother varies her velocity, while the
baby tries to follow, but is constrained to move with discrete, constant velocities. If the mother and baby
become separated, the mother quacks angrily. The student doubles the number of constant velocity segments
and shrinks their duration, trying to help the baby achieve a good approximation to the mother's motion. This
illustrates the process of integration by approximating a curve with rectangular areas and taking the limit as the delta time goes to zero. It is one approach to an aspect of the Fundamental Theorem of Calculus.

Scripting Architecture

MathWorlds uses drag and drop to enable easy layout and customization of an activity. To make the MVT activities, we dropped graphs into place and dragged actors to the graphs to link their motion to the graph plot. Drag and drop is sufficient for layout, but does not allow authors to add behaviors to the activity. To add behaviors to MathWorlds, an author writes a script.

Scripting is lightweight programming in a simple language. The activity author or teacher can put scripts in the menu bar or the tool bar, and these scripts can have complete control of the MathWorlds interface, including the underlying mathematical elements and simulation characters. The essential principle of scripting is that every action that is possible via mouse manipulation is also possible via scripted statements in a programming language. Thus scripts can be used to record direct manipulation actions, automate actions without intervening mouse use, or extend the interface.

Scripts are incorporated into an application via Apple's Open Scripting Architecture (OSA). OSA [Apple, 1993] comprises several levels:

"AppleEvents" are a mechanism for sending an application commands that correspond to mouse-driven actions. Each AppleEvent corresponds to one type of manipulation: e.g., opening a window, editing a velocity graph, or running the simulation. Many commonplace applications now support AppleEvents (i.e., HyperCard, Eudora, Excel). By supporting AppleEvents, MathWorlds allows itself to be controlled by a script and to communicate directly with other AppleEvent aware applications to exchange data, send mail etc [Roschelle, 1995].

"AppleScript" is a simple programming language from Apple that produces programs that send AppleEvents. AppleScript programs can customize, extend, or connect capabilities of applications. It is freely available as part of Apple's System 7.5.

"OSA" provides tools for loading, storing, compiling, executing and displaying scripts. By making OSA calls, MathWorlds can display, execute and store user-written scripts, integrating them into its built-in capabilities.

Extensive use of these Apple features results in a "factored" program, which separates direct manipulation controls from the data model and the display. In a factored program, the data model and display change only in response to AppleEvents, which can be generated either by direct manipulation or by a script. Factored programs are easier to develop, extend and maintain, since each functional module is independent of the others, and all actions and data are passed between modules via a single, well defined software protocol.

Benefits Of Scripting

By adding support for OSA/Scripting/AppleEvents, educational programs can gain considerable educational benefits. We demonstrate this with a series of a examples taken from the above activity.

Recordability

A key benefit of supporting scripting is the ability to record all actions in the interface, similar to the way Excel can record macros. Apple's ScriptEditor program can record actions in any AppleEvent-driven application, including MathWorlds.

Recording has multiple uses. To learn AppleScript, one can turn on recording, perform some actions, and see the equivalent scripts. In addition, recording can be valuable for software evaluation. An evaluator can record what students do with the software to see which commands they use and how. The same capability can be used for assessment, to store a record of students actions as they work on an activity. Recorded scripts can also be transmitted over a network for remote assessment.
Extensibility

Scripting provides a way to extend the capability of an application beyond those initially conceived by the developer. In MathWorlds, a Scripts Menu loads any scripts that the teacher or student put into the "Script Menu Items" folder. These scripts become commands that function like built-in menu commands. A script file can also be dragged to the tool bar, creating a button that runs the script via mouse click. Each tool bar script can even be given its own icon.

In the mean value theorem activity, we use scripts to provide a set of transformations that are not built in to MathWorlds. For example, we want students to explore what happens to the mean value when the duration of each segment of velocity is doubled. Other interesting transformations include reversing the time order, inverting the velocity magnitudes, scaling the magnitudes, and arranging linear growth from any given initial velocity to any given final velocity.

The scripts that implement such transformations are relatively simple. For example, this script will double the length of each velocity:

```plaintext
tell document 1 of application "MathWorlds"
tell motion "fred"
    repeat with i from 1 to number of velocity
        set deltat of velocity i to 2 * deltat of velocity i
    end repeat
end tell
end tell
```

Scripts can control window and graph bounds, creation and deletion of program and interface elements, make graphs visible or invisible, and so on.

Connecting to Scriptable Services

Scripts also make it possible to connect applications, as long as both applications understand AppleEvents. A simple example is the following "Mail Notebook Via Eudora" script, which will launch the electronic mail program Eudora, attach the currentMathWorlds notebook, and send the message to the first author of this paper.

```plaintext
tell application "MathWorlds"
    set mydoc to file spec of document 1
end tell
tell application "Eudora"
    set mymessage to (make new message at end of mailbox "out")
    attach to mymessage documents { mydoc}
    set field "subject" of mymessage to "ASimCalc document"
    set field "to" of mymessage to "jeremy@soe.berkeley.edu"
    connect sending true
end tell
```

Placing this script inMathWorlds allows students to mail us their notebooks with a single mouse click.

Scriptable services can also input data from another application to MathWorlds. For example, we have collaborated with the authors of MacMotion to allow MathWorlds to gather motion data from a motion probe and display it in a MathWorlds graph. Similarly, we have collaborated with the authors of FunctionProbe to use their symbolic algebra parser. The script below will pop up a dialog in MathWorlds in which the user can type an expression, such as "f(x) = 2X - 4." The expression is then evaluated in FunctionProbe and displayed in an MathWorlds graph.

```plaintext
set answer to (display dialog "Enter a function:" default answer "f(x)=")
set fn to text returned of answer
```
tell application "FP v3.0.4d"
    set result to Eval Function fn from 0 to 7
end tell

tell document 1 of application "MathWorlds"
    set velocities of Math Object "fred" to result
end tell

Thus scriptable services allow MathWorlds to use background capabilities of other applications for mail, data collection, or symbolic function evaluation. These capabilities appear to be integrated into our application; however, the effort to connect applications was limited to writing a script. This very powerful capability enables an educational program to take advantage of the many services available in other applications or on the Internet.

Configuring and Customizing

Scripting provides a way out of a common tension in educational software. On one hand, the more features and flexibility an application offers, the greater its usefulness. On the other hand, when students are working on a task, a constrained set of carefully tuned features can help keep students focussed on their work. Traditionally, educational developers have had to choose one end of this spectrum. Scripting offers a better solution by enabling teachers and curriculum authors to change the interface.

Curriculum integration is the complement to a customizable interface. The features we mentioned above, like connectivity, extensibility, and configurability enable the MathWorlds notebook to be re-used in many different educational activities. It then becomes necessary to organize those activities in a curriculum. Here, as above, scripting is a major help.

One tool for integrating curriculum is HyperCard, which provides good capabilities for hypertext organization of a diverse set of activities. We have written a HyperCard browser for the mean value theorem activities. This browser lets the student select among a wide ranging set of particular tasks. Each task comes with a particular card, that explains the task to the student. Furthermore, each task card has a "set up" button. This button contains a script that acts on the MathWorlds simulation. It will completely configure the interface to match the current task. Configuration might include opening or closing notebooks, re-arranging the size and position of windows, linking motions to particular graphs and animations, and customizing the tool bar.

We are also experimenting with the use of the World Wide Web as a curriculum delivery system. Like Hypercard, the WWW allows teachers and students to browse among a large set of "task pages" via hypertext links. Moreover, it is possible to download a script file from a remote source at the press of a button. Mosaic or Netscape (WWW browsers) can direct this script file to MathWorlds, allowing a remote script to configure the student's local version of MathWorlds. This makes it possible for globally distributed curriculum guides to set up local simulations and notebooks for students to use.

Combining Interfaces

The above example combines HyperCard with SimCalc MathWorlds. Generalizing such combinations promises many benefits, especially as common tools are re-written as scriptable modules. Scriptable applications allow the teacher or curriculum author to mix and match interfaces of many applications to achieve an overall set of capabilities. Combining interfaces can save tremendous amounts of time and money; instead of coding every interface the student will need in C++, we are able to ‘borrow’ interfaces from other commercial applications, achieving a connection via scripting.

For example, we do not yet have a table formatter in SimCalc MathWorlds. Instead we are using FaceSpan, which is a completely scriptable user-interface builder. Within a few hours we were able to build a FaceSpan application to show MathWorlds data in a table. By dragging it to the tool bar, the table becomes an integrated MathWorlds element. In the mean value theorem activity, we use external word processing and spreadsheets.

The ability to customize and combine interfaces allows a teacher to gain access to and present a wide range of curriculum tools through a single interface that uses a single organizational metaphor. Teachers can also leverage their existing knowledge of spreadsheets, Hypercard, etc. to develop and present new curriculum.
Interactive Guides

Although we have not yet implemented this possibility, it is worth noting that scripting opens up significant new possibilities for interactive guides. The recordability features enables a human or computer guide to see each action that the student performs in the interface. It would be possible to process this stream of events and thereby plan a tutorial interaction. A remote person or computer guide could then send scripts to MathWorlds.

Such guides can be rewritten without access to the underlying C++ source code of MathWorlds - the public scripting interface allows access the level of actions that a tutor should require. Therefore, guides could be supplied by an open, free market.

Conclusion

The example of the mean value theorem activity in SimCalc MathWorlds demonstrates the many powerful benefits that are made available by thoroughly incorporating the single mechanism represented by AppleEvents, AppleScript, and OSA. These benefits include the ability to record student actions, extend the menus, connect to other services, customize the interface, integrate curriculum, and combine interfaces. Each benefit makes cost-effective development and use of sophisticated educational capabilities much easier.

We believe these benefits will multiple even further with forthcoming "component software" platforms such as OpenDoc and OLE [Udell, 1994]. These will make the job of combining scriptable modules into a project-driven student activity much easier. Modules make it possible to combine capabilities from many software products into a single project, and scripts allow tight integration of distinct modules.

Although educational developers do not often attend to software architecture issues, we believe it is now time to do so. The common "application" format is limiting educational possibilities by restricting opportunities for extending, customizing, or connecting software modules. A more open "scriptable" architecture is now within easy reach, and promises a compelling array of enhancement possibilities. The educational technology research and development community should be exploring these possibilities and finding ways to realize their potential in educational settings.

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Learning Computer Skills in School

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Abstract: The purpose of the study was to investigate the processes between the learner and the computer to understand the learning with and about the computer. The subjects were 11 upper primary school students. The study applied qualitative methodology and the data were collected by thinking aloud protocols, observations, and interviews. The results showed that the students applied 11 different strategies in their working with the test problem. The study analyzed also the subjects’ problem solving processes and the differences between good and poor and respectively experienced and inexperienced learners.

Introduction

The processes underlying the learning to use a computer have interested researchers since the late 1970s and the early 1980s. The main interest has usually been in the effectiveness of the learning process. For instance, Carroll and Mack, Biemans and Simons, and Ropo have addressed this question (see Carroll & Mack 1984, Biemans & Simons 1992, Ropo 1992). Ropo focused on the strategies that the university students applied in learning to use a word-processing program and found that good learners focused on understanding the way the program and the computer worked (Ropo 1992). They were also more goal oriented than the poor learners having better defined objectives for their work with the program. Biemans and Simons (1993) noticed that expert computer users (experienced) had better self-regulation skills and that they were better able to apply those skills than novices who seemed to need more outside help to direct the learning processes. Carroll and Mack (1984) showed that learning by reasoning and problem-solving required a good representation of the problem space. To be successful a student had, for instance, to know the relevancy of the different ways of processing information.

We assume that the learning of computer skills takes place in a contextual problem-solving process in which the learner and his/her context are in continuous interaction. The learner monitors and regulates his/her thinking and acts by representing and rerepresenting the encountered problems and trying to invent and apply different strategies to the situation until the problems have been solved. Strategies are regarded as the students’ approaches and concrete acts in the problem-solving. The process of problem-solving can, consequently, be described as a step by step process in which the subject initiates strategies in a specific order to reach the goals related to their application.

The study focused on the above type of processes in the learning to use a computer program. The specific research questions were:
a) what kind of problems the students have in making a graph,
b) what kind of strategies the students apply in solving a test problem and how effective those strategies are,
c) how do good and poor learners and respectively experienced and inexperienced computer users differ from each other?

Method

The subjects were 11 (9 boys, 2 girls) upper primary school students (7th through 9th graders). In the study situation the subjects were using MS Works program for PC computers. All the subjects were unfamiliar with the graphics part of the program before the instruction. The teacher taught first the main characteristics of the program in about half an hour using examples. After that the subjects were provided with half an hour time slot
to practice with the program asking the teacher’s help if needed. The data collection followed this practice period and took about an hour. During the data collection a subject was given a task in which newly acquired knowledge and skills were needed. Both the teaching and test sessions were tape-recorded and all the test sessions were transcribed afterwards.

Overall, the study utilized qualitative methodology and the data were collected primarily by asking students to think aloud during their working with the given task. In addition to this, observations of students working with the problems were applied. Observations were aimed at finding out the main characteristics of the applied strategies. The observer made notes during the sessions. To increase the reliability of the observations all subjects were also interviewed after the test sessions.

Results

The Nature of Problems in the Test Task and the Problem-Solving Process

The results were analyzed in the order of the study questions. First, the problems that the students had were categorized. The thinking aloud protocols were used for this. The test task was to make a graph using the data from an imaginary kiosk business in which the sales reports were available. The ideal problem-solving process for this kind of task can be divided into seven steps shown in Table 1. The table indicates the amount of problems students had in each step.

Table 1: The problems encountered in problem-solving (the rank order of the subjects is listed in parenthesis)

<table>
<thead>
<tr>
<th>Step</th>
<th>Problems</th>
<th>Amount of problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Filling the table in which the graph is based</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>11 - calculating mean or total sum (Ic, IId)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12 - writing into the table (Ic, IId)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>13 - figuring out what is needed for the graph (Ic, IIa, IIb, IIc, IIIa, IId)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>14 - moving numbers in the table (Ib)</td>
<td>1</td>
</tr>
<tr>
<td>2)</td>
<td>Opening the graph</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>21 - figuring out the content of the graph (what numbers to use) (Ia, Ic, IIa, IIIa, IIIc, IIIId)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>22 - making the x- and y-series (Ib, Ic, IIb, IIIa, IIIc, IIId)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>23 - calling the graph on the screen (Ib, Ic, IId, IIIc, IIId)</td>
<td>5</td>
</tr>
<tr>
<td>3)</td>
<td>Choosing the format of the graph</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>31 - figuring out the most suitable graph (the most informative and suitable, mathematically correct) (Ia, IIIa)</td>
<td>2</td>
</tr>
<tr>
<td>4)</td>
<td>Clarifying the graph</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>41 - making the legend (Ib, IId, IIId)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>42 - inserting titles to the graph (Ib, IId, IIIc, IIIId)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>43 - naming the axes in the graph (Ia, IId, IIIb)</td>
<td>3</td>
</tr>
<tr>
<td>5)</td>
<td>Making another graph</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>51 - saving the old graph while making a new one (IIIa)</td>
<td>1</td>
</tr>
<tr>
<td>6)</td>
<td>Naming the graphs</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>61 - naming the graph (Ic, IIb, IId, IIIb, IIIc, IIIId)</td>
<td>7</td>
</tr>
<tr>
<td>7)</td>
<td>Assessing the graphs</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>71 - assessing and checking different parts of the graph (Ib, IId, IIIc)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>72 - validity inferences of the graph</td>
<td>6</td>
</tr>
</tbody>
</table>

All the subjects started the test by doing the calculations followed by opening the graph on the screen. After this two students tried to select the format of the graph and the rest of the subjects started clarifying the graph. Four subjects (Ic, IIb, IId, and IIIc) skipped several stages that are important in problem solving. Seven subjects did more than one graph. Four of the students did not evaluate their achievements.
Program specific problems were analyzed from thinking aloud protocols, observation minutes and grading the graphs students produced in the test situation. In addition to the program specific problems students had lots of general working problems. General problems were mainly detected from the observation protocols. The most common problems were 1) the lack of monitoring one’s progress (Ic, IIc, IId, IIIc, IIIId), 2) the lack of understanding what one is doing (Ic, IIc, IId, IIIc, IIIId), 3) the lack of holistic representation, or problems in finding important details (Ic, IId, IIIa, IIIc, IIIId), 4) the problems in finding and using efficient strategies (Ic, IIb, IIc, IIIb, IIIc, IIIId), 5) general uncertainty of oneself (IIb, IIc, IId, IIIb, IIIId) and 6) passivity in trying anything (IIb, IIc, IId, IIIc, IIIId). The subject numbers listed in parentheses show that most of the general problems were associated with the inexperienced computer learners’ processes (II and III students).

Students’ Problem-Solving Strategies

The strategies were categorized from the thinking aloud protocols collected in the test situation. The results showed that students applied 11 different strategies in their problem-solving. Those strategies are listed in the following Table 2.

Table 2: Strategies used in the test task

1. Inquiry
   • asking advice immediately after encountering the problems, continuous inquiry as a method in the problem-solving (8 students)
   "I don’t know if I can do it from this.. I can make out of this juicedata.. can I?"

2. Memorization
   • reminding oneself of the instruction (teacher, practice sessions etc.); recalls one’s own procedures from the teaching session (7 students)
   "Do I remember this.. oh it is so hard to recall all of this.. I think it was like this..."

3. Systematic trial
   • explores different and varying alternatives while performing the task. Exploration is systematic and goal oriented (4 students)
   "Ok, let’s try this.. oh no this doesn’t seem to work... well, aren’t there 6 of those.."

4. Trial and error
   • explores different alternative ways non-systematically, lots of mistakes and errors, new trials after errors, performance is not productive and reasoning behind the trials is unverbal (4 students)
   "Would the totals work in this.. Is it this one.. ok try again.. what should I put in title.. Oh it doesn’t seem to work.. (Tried 3 times).. Oh no, I don’t know"

5. Observation of performance
   • selects information carefully, categorizes perceptions, observes one’s own processes and the results of efforts (3 students)
   "I thought that I’d do it like this, let’s see what it says.. If I do all like this then it will show me everything by months.."

6. Reasoning
   • proceeding by thinking and reasoning, however, monitoring one’s success impartial (3 students)
   "this would make it easier if I calculate the amount of money from each month.. is this enough or should I continue.. well"

7. Applying earlier experience
   • Based on earlier experience with computers, activating earlier representations of computer programs and own skills with them (2 students)
   "nothing new has appeared yet in these classes..(did you relate this to something you learned earlier?) yes to Quatro Pro.."

8. Using notes
   • makes notes on teaching and uses them while solving the test tasks (2 students)
   "if I just a little look my notes to makethis.. if I do a table then I should find it here.."

9. Creative imagination
• uses imagination in problem-solving (1 student)
   (was thinking of the kiosk owner, who had a problem like this) “oh yes.. I can see juice is doing well.. And.. well ...cookies... We try to get rid of them.”

10. Atomistic representation
• focuses on facts, details and restricted aspects in the problems (8 students)
  “well all the things are so mixed in my head.”

11. Holistic representation
• focuses on main points, combines details under a main theme or topic area (3 students)
  “I try to understand the whole picture... The details after I figure out the total picture”

Applying only one strategy is not enough in the problem-solving and learning process. All the subjects applied at least three different strategies. The most effective combination of the strategies seemed to be ‘the observation of performance’ combined with ‘the systematic trial’ and ‘holistic representation’. This resulted in a quick learning of the program characteristics whereas ‘inquiry’ combined with ‘memorization’ and ‘atomistic’ representation seemed to lead into surface level learning and low scores in the test.

Differences Between Good and Poor and Experienced and Inexperienced Learners

Our last research question was how the applied strategies relate to the overall performance in the test task. This was analyzed by dividing the learners into two groups, namely, good and poor on the basis of their grades in the test task (performance was graded by the teacher). The criteria for the grading were fluency of filling up the table, clarity of the graph, and fluency in using the program. Grading scale was from 4 to 10. The analyses indicate that such strategies as ‘applying earlier experience’, ‘holistic representation’, ‘observation of performance’, and ‘systematic trial’ were strategies more often used by the good learners. Experienced students seemed to apply different types of strategies compared to inexperienced. More typical for the experienced subjects seemed to be the use of ‘systematic trial’, ‘observation of performance’, ‘applying earlier experience’, and ‘holistic representation’. Inexperienced subjects used such strategies as ‘atomistic representation’, ‘using notes’, ‘reasoning’, and ‘trial and error’. The average grades for experienced and inexperienced students were: Experienced (I) = 8,5, some experience (II) = 8,0, and inexperienced (III) = 7,1. Although two of the experienced subjects graded high in the test it is important to notice that one of the experienced graded 7 which is much less than many of the inexperienced subjects. Besides, one student from the group II was graded 9,5 which is much more than the average grade in the experienced group. The data overall indicate that experience is closely related to the learning process and its results but that in the individual subject level there are exceptions of this rule. Further studies are needed to elaborate the relations between the experience and achievement. However, in our case the student performing well without much experience with the computers seemed to be a student whose school performance overall was excellent.

Discussion

The purpose of this study was to expand the understanding of the learning process with a computer involved. We may summarize the results with three conclusions. First, the initial stages of the problem-solving process seemed to be most difficult. Fifty percent of the students’ problems were on the first two stages, namely filling up the table and opening the graph on the screen. Also the last part of the problem-solving, assessment of the results, was a problematic stage. Second, the students applied a multitude of strategies in solving the problems. The variation indicates that the students have a lot of strategies for overcoming the different obstacles in their search for solutions in the problem-solving and learning processes. Third, differences were found both between the good and poor students and the experienced versus inexperienced students. The most important seemed to be the nature of the strategies that the subjects applied. The results indicate some implications for both the theory and practice. First, the data show that performance is always related with the nature of the strategies students use during the learning process. Second, the study reveals important aspects of the nature of effective strategies in learning to use a computer. Direct teaching of those strategies may enhance the learning processes of all students. Third, the data showed that experience with computers is not necessarily related to effective learning process. This result is an interesting one and confirms our assumptions that effective strategies can be learned and used without long experience. However, further studies in the topic area are needed.
References


Software Factories for Active Learning Environments

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Abstract: The creation of authoring tools like HyperCard, Supercard, Director and Authorware have been very important in the development of multimedia programs, including educational multimedia applications. They will not, however, help to improve the educational effectiveness of multimedia applications. Nor will they drive the production costs down far enough to make educational software economically feasible. One alternative, which will simultaneously improve the quality of software and reduce its cost, is to produce "task-based" authoring tools. This paper argues for this approach and presents a set of design guidelines for creating such tools. In particular, it argues that authoring tools should be based on three basic principles: Task-based programming languages, Software Factories and Case-Based Design.

Introduction

Creating effective educational software has always been a costly enterprise, principally because it requires a wide variety of expertise, ranging from software engineering skills to knowledge of the domain. Today's multimedia world raises the stakes even higher, requiring significant media production expertise as well as user interface design knowledge. Authoring tools like Hypercard, Supercard, Director and Authorware help reduce the production costs of producing multimedia software by reducing the software engineering burden. These tools have been incredibly important in the development of multimedia by allowing the rapid creation of a large number of prototypes and simple applications. But while these authoring tools do reduce the software engineering requirements, they do little to encourage the production of quality educational software. The unfortunate result is that these tools seem to produce programs which use a "page turning architecture"—programs which give students a screenful of text or pictures and a button to advance to the next screenful of text or pictures. [Schank, 1994a] These are the easiest programs to build and require neither a sophisticated educational theory nor extensive software expertise. The "multimedia" versions of page-turning programs aren't significantly different—it matters very little whether the "pages" contain text, graphics or movies.

One type of educational software we should be concerned about building economically can be characterized as Active Learning Environments [Schank, 1994b]. This refers specifically to software which giving learners a specific task to accomplish, provide a rich environment in which to engage in that task, and offer tutoring and coaching to help students succeed. Many research groups are working and testing this kind of software and have found it to be successful from both motivational and cognitive perspectives [Bransford, 1990; Brown, Collins, & Duguid, 1989]. Two examples are Sickle Cell Counselor, which teaches about sickle cell disease by having students perform blood tests on people who are considering having a child [Bell & Bareiss, 1993] and Jasper, in which the student learns algebra by helping Jasper Woodbury get his fishing boat home before dark [CTGV, 1991]. Both of these programs provide the student with a very concrete task and help the student to accomplish that task.

This combination of a task environment and tutoring is what distinguishes these systems from multimedia encyclopedias and other information resource software. It also distinguishes them from games like SimCity which provides a task environment but doesn't understand anything about what the student is trying to accomplish and, therefore, can't offer much help or advice. Providing tutoring means the software needs to include a significant amount of domain specific content. It also means that the software engineering issues can
become quite complicated. Active Learning software requires many elements that make it costly to build, including a specific educational task, complex software engineering and a great deal of content knowledge. It is this type of software that is especially difficult to produce economically. Even if demand for interactive software in general increases, nothing guarantees that educationally effective software will be the result. The current competition is rather easy to beat—encyclopedias and Nintendo. It is just as easy to make something more dynamic and interactive than an encyclopedia as it is to make something more educational than Mortal Kombat. So how can we make good educational software easier to build? By making smarter tools.

Building Tools

Building tools to make software development easier isn't a new idea, of course. The tools we want to create are a bit different, however, because we want them to be used by content experts—people who know a lot about something, would like to teach it, but don't know the best way to teach it and certainly don't have the engineering skills necessary for building good software. We need to provide them with the expertise that they don't have, namely, the software engineering skills, the user interface design knowledge and, most importantly, the educational task. Most tools for creating multimedia applications concentrate on simplifying software engineering, media production or interface design [Visual Basic, Hypercard and Macromedia Director all fit into this category]. Few tools try to help designers with the process of creating educationally effective tasks for students. There are several exceptions, however, including work being done by Tom Murray at UMass Amherst, Benjamin Bell at Columbia University and several people, including the author, at the Institute for the Learning Sciences. This paper relates the approach to this problem taken by the author and, to a large extent, at ILS in general. The approach can be summarized by three basic principles: Task-based languages, Software Factories and Case-based Design.

Task-based Languages

The computer industry has produced many programming languages which are unlikely to evolve into the kinds of tools we want. The simple reason is that traditional programming languages have been built for programmers—people who understand how computers work. Assembly languages, which are based on the actual architecture of the computer, are the most obvious case of this and today's programmers rarely use it. So-called "high level" languages like C and Pascal are more abstract, but require an understanding how computers work at a fairly deep level. They introduce constructs that take a step away from the registers and the stack, providing data structures, named variables, functions, looping constructs and the like, part of whose purpose is to automate much of the annoying accounting that goes along with programming in assembly. These constructs also allow programmers to think about programs at a higher level. Although this is not the place to characterize precisely characterize this level of abstraction, it can be summarized as "information processing". The idea is that there is a set of information and a set of procedures for modifying that information. Programming consists of setting up the data and running the procedures on that data.

The "information processing" model provides a very important capability. It allows a programmer to take a step away from the computer and think conceptually. A programmer can, for example, create a "person" data structure with "name" and "address" fields and build a "relocate-to" function that changes the person's address. Object-oriented languages, especially, encourage thinking in terms of the data structures and operations rather than bytes and registers. It is still up to the programmer to translate this conceptual description of the program into the particular programming language. Which means that while these languages allow programmers to think conceptually about their programs, the program still must be expressed at a highly technical level. Experience has show us that this prevents these languages from being usable by anyone other than computer professionals. Furthermore, allowing a designer to think conceptually isn't the same as helping them to think conceptually. Thus high-level languages will continue to be tools for technically trained professionals.

In the last ten years, though, authoring tools" have begun to provide some help. The first of these was Hypercard, developed by Bill Atkinson of Apple Computer. Hypercard was revolutionary. In many ways,
Hypercard and other authoring languages live up to their promises—they allow people who do not understand how computers work are able to build computer programs using them. Hypercard achieved this by rejecting both the computer's architecture and the information processing model as the basis for a programming language. So what does it use instead? Hypercard's model is based on a naive view about how computer programs work. This naive view of computer programs goes something like this: The computer presents a "screenful" of information. The user takes an action by, say, typing some information into a field and pressing a button. The computer responds by bringing up another "screenful" of information. And so on. There is no reference to data structures, function calls and certainly no mention of registers or bytes. This way of understanding how computers work is the "computer as monitor" theory—so named because it focuses attention on what is on the display. We've all heard stories about thieves stealing computer monitors and leaving the CPU behind, which is good evidence that this theory is quite prevalent. In any case, Hypercard allows people with this understanding of computers to build programs. Each "card" in a Hypercard stack is a "screenful" of information and it is easy to create buttons to link a cards to each other. A less glib way of describing Hypercard is as a tool for creating programs that conditionally display static information. Unfortunately, a program that links a set of static information does not make a good educational software program. And, as one would expect, the vast majority of software created in Hypercard by non-programmers is encyclopedia-type software or "page-turning" software sprinkled with multiple choice tests.

Hypercard, then, helps non-programmers create software which may or may not be educationally effective. It achieves this because it isn't based on technical concepts but, rather, the conceptions of non-programmers. This isn't a big enough step or, rather, it isn't a step in quite the right direction because, unfortunately, the "computer as monitor" model is not a good basis for educationally effective interactive software.

The alternative is a development environment that discards the computer-centered view of programming and allows software designers to work with concepts that are already familiar to them. An example will help illustrate this point. At ILS we've developed a system called "Advise The President" in which a student learns about an historical event (the Iran-Hostage Crisis in one instance) by preparing a report to the President about what to do. This program can be described in a variety of ways. We can talk about it in terms of memory addresses and register operations (the computer architecture view), in terms of data structures and function calls (the information processing view) or in terms of screens of pictures, buttons and text fields (the computer as monitor view). None of these are the way we would describe the program to, say, a 7th grader or a history professor. Instead, we'd talk about the program in terms of the task the user is trying to accomplish and the objects and activities involved in accomplishing that task. The fundamental units of the program are the report, the alternatives under consideration, the student's opinions, the evidence for and against certain opinions, etc. These are the terms of everyday discourse and are understood by everyone. They are the terms of the activity or task the user is pursuing which, in the end, is what determines the success of a learning environment. These, therefore, are the terms that we should use for building authoring languages. In place of commands like "show graphic 'xyz' at location 100,100"", the programming language will have commands like "open the report to the 'Blockade Cuba' section". What we want, in effect, is a task-based programming language.

One advantage using a task-based programming language is that it should allow designers to create software without technical training. Working in a task-language means, of course, that they will have to learn that task-language. There are two reasons why this is better than having to learn a traditional programming or scripting language. First, it should be easier to learn because task languages, for the most part, will consist of everyday concepts. The second advantage is that new knowledge the designer needs to acquire about the task language is actually relevant to the learning process. It is better for the designer to be thinking about the task the student is engaged in rather than pictures and buttons and global variables. This change of emphasis is immensely important educationally.

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1 Hypercard does have a scripting language beneath it which allows it to be more dynamic. To use these features effectively, however, a developer needs to have a technical understanding of the "information processing" model of computer programming required by more traditional high-level languages. Hypercard is better in this regard because it allows authors to use just as much of that underlying programming language as they need—something usually not possible in programming languages.
There are problems associated with creating task-based development environments. One problem is developing an adequate model of the task that is both rich enough to allow for good educational software and simple enough to be used by content experts. This problem is not insurmountable although it require careful construction of representations akin to those used in the artificial intelligence community. The larger problem seems to be that each different task we'd like to support will require it's own task model and, therefore, it's own custom "programming language". There will need to be different authoring tools for building Advise the President, Sickle Cell Counselor and Jasper. This is unavoidable. It's also not necessarily a bad thing. It shifts much of the burden of software development from the content experts onto the creators of the tools, who must now create a new programming language and development environment for every type of educational software program they would like to build. This is just where the burden should be shifted, though.

**Factories not toolkits**

Task-based programming languages won't, by themselves, allow content experts to create educationally effective software. The problem with a computer programming tool, even a task-based tool, is that it allows too many different kinds of programs to be built. It may seem strange to want a programming language that prevents you from creating certain kinds of software. But the advantage is that we can make our tools build good software and, at the same time, make them easy to use by non-computer professionals. We can do this by sacrificing the generality of traditional software development tools. To understand this we need to examine the approach taken by traditional software development tools more closely.

Actually "programming tool" is a bit of a misnomer and we should refer to "programming toolkits" instead. Software development aids are really collections of methods for accomplishing certain specific tasks. Take the capability creating a button. Like a hammer, these allow the tool user to perform one very specific task. A single tool isn't worth much, but grouped with related tools it forms a toolkit which can create more complex structures. Different toolkits are needed for different kinds of structures; while a plumber and a carpenter may share many tools they certainly have different toolkits which are optimized for fixing plumbing and building cabinets. The same is true of various software development environments—many of the primitive capabilities are the same but the overall collection of capabilities makes some tasks easier to accomplish than others.

Carrying the metaphor a bit further, an expert craftsman can create wonderful, unique objects with the right fundamental tools and materials. These hand-built, custom objects are hard to build and can be quite expensive. If we give the same materials and toolkit to a novice, the items they produce will be of very poor quality. "Do-it-yourself" kits are a way of overcoming this problem. These kits give a relative novice a toolkit, some materials and step-by-step instructions. The kit can't help the novice build anything else—but at least they can build one thing pretty well. This automation is taken further in factories, which are essentially high-volume kits for complicated objects. Factories and do-it-yourself kits enable people who aren't experts to build complicated artifacts efficiently. They pull together a set of materials, some tools for operating on those materials and a formal procedure for putting the materials together using the tools. At the same time they ensure that only high quality products are created. If we want to do the same in the world of educational software we should be building software factories, not software toolkits.

Unlike toolkits, factories require that you decide what, exactly, the factory will be used to create. Of course we want to make "effective educational software programs". How do we go about doing this?
We'd like our factory to only create programs inside the "Effective Programs" space [see Figure 1]. One approach is to try and change a general programming environment so that it only creates programs in the correct space. This amounts to shrinking the big circle so that it becomes the smaller one. We would do this by removing some capabilities of the language and adding some other constructs we thought would be useful. In terms of our "toolbox" analogy this would be akin to removing the tools and materials that cause unsuccessful buildings to be created. The problems with this approach should be obvious—the problem doesn't lie in any of the particular tools or materials. Similarly what distinguishes good educational software from other software is not whether it was written in C++ and has buttons and animations, but rather whether the interaction the student has with the program helps them learn something.

Hypercard, for example, provides tools which make it easy to create "cards" in a stack. Both good and bad programs built with Hypercard will contain cards, buttons and fields, but the interactions student's have with the programs will be very different. Hypercard is only a toolkit and, as such, doesn't do much to encourage or prevent particular kinds of software from being built. This is not to say that different toolkits don't make some programs easier to build than others—one can imagine a general authoring tool which tends to make better software than Hypercard. But the problem remains that general programming languages won't, by definition, make enough restrictions on (or provide enough encouragement for) the type of interaction the student will eventually have with the program.

An obvious alternative to "removing tools from the toolkit" is to start from scratch and try to create a programming environment which produces only effective programs. If we could do this it would be great. There is one major problem—it requires a strong theory of what an effective educational software program is and how to make one. At this juncture I don't believe anyone has a theory that is detailed enough to be implemented as an authoring language.

Case-Based Design

The situation is not desperate, however, since we do know something about good educational software and how to make it. In particular we know that certain applications—like Sickle Cell Counselor and Jasper—are effective learning environments. One successful approach for dealing with domains without an overall theory is case-based reasoning [Riesbeck & Schank, 1989]. The approach of case-based reasoning is to take an existing solution and attempt to modify it to solve the current problem. In the context of software development this means taking an existing program and changing some parts of it to make a new one. This will allow us to create a small set of programs that are very much like an existing, successful program [see figure 2]. These programs are very likely to be successful as well.
If Sickle Cell Counselor were the only kind of educational software program we ever wanted to create then this would be the end of the story. What makes Sickle Cell Counselor work as a program, however, is not the same thing that makes Jasper work as a program. We'd like to be able to create a wide variety of effective programs that work in different ways.

The approach taken by traditional programming languages and authoring tools is to expand the range of programs a single tool can create by making that tool more general. Unfortunately the more general we make the tool, the more likely people are to use it to create ineffective software. Furthermore, as the programming language gets more abstract it gets more difficult for novices to use. As we said before, content experts will only be able to build programs using software factories, not toolkits. If we want content experts to be able to build different kinds of programs then we need different factories. This is consistent with CBR systems which expand the range of their abilities by adding items to the case base, as shown in Figure 3:

This is more work for the tool developers because they need to build one factory for each kind of program. This is a daunting task but there is no avoiding it. "Toolkit" approaches have failed to allow non-computer programmers to easily build software. They've also failed to provide the guidance necessary to produce good educational software. It's time to build factories instead which will make it easy to build particular kinds of effective educational software. At ILS we've initially identified several different types of educational software programs we'd like to be able to build and have begun to create tools to build them. We believe that eventually these tools will allow content experts to create educational software without the help of computer programmers. The first of this was created to make near-neighbors of "Sickle Cell Counselor" and has been used effectively by non-programmers (including teachers) to create software [Bell, 1995; Bell & Korcuska, 1995]. Significant work is ongoing at ILS to create tools for other types of learning environment software, the author's Evidence-based Reporting tool [Korcuska, Herman, & Jona, Submitted] which is based on Advise the President [Bareiss & Beckwith, 1993] and Broadcast News [Kass, Dooley, & Luksa, 1993].
Conclusion

Active Learning Environments are difficult to build and it is important to create tools that allow them to be constructed efficiently. While generic authoring tools have allowed people without extensive technical training to create software, they have not provided much help with creating educationally effective software. This paper has argued that in addition to continuing to improve generic authoring tools, researchers and developers of educational software should also focus on creating highly specific, constrained "software factories" which interact with authors using the language of the student's task rather than the language of the computer. This kind of tool will allow the production of educational effective software by non-technical content experts. Because of the narrowness inherent in such tools, this approach requires that a significant number be created, each based on an existing, successful example of educational software.

References

MediaADE : The MHEG-based Distributed Multimedia/Hypermedia Application Development Environment

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Abstract : Network technology has been developed rapidly and the use of multimedia data has been increased dramatically. So, we need the multimedia/hypermedia information system that can code multimedia data in order to represent their attributes, save in database and transfer them to the users. In this paper we design distributed multimedia/hypermedia application development environment(MediaADE) so as to satisfy the above requirements. The MediaADE use MHEG standard to represent temporal and spatial synchronization, real-time transmission form, final form representation, and interchangeable form of multimedia data. We design MHEG engine to present coded MHEG object to users. Also, we design the interface of communication and database for the purpose of transmission and storing MHEG object in client/server environment. Finally, we design the API that assists programmers and users to develop distributed multimedia/hypermedia application easily.

Introduction

It is difficult to standardize the stored and transmitting format of multimedia data through network because multimedia data generally large, are not regular in size, and have difficult in presenting by one keyword [Kretz & Colitas, 1992]. And it is difficult for the existing multimedia/ hypermedia development environment to interchange and reuse information, due to the difference of stored format in dissimilar environments.

Now MHEG(Multimedia and Hypermedia information coding Expert Group) which standardized by ISO/IEC JTC1/SC29/WG12 has defined encoding format for interchanging between multimedia data through network, presenting multimedia/hypermedia objects, spatio-temporal synchronizing, real-time transmission, and presentation of final form, etc.[ISO13522-1, 1994]. This standard supports functions in order to interchange various type of media. Each media data is coded following international standard such as JPEG, MPEG, etc. MHEG exhibits the presentation of hypermedia and the standardization of exchanging. There are many applications that are possible by using MHEG, such as training/education, simulation/game, sales/advertising, office information system/engineering documentation, etc. To develop these applications, MHEG engine is necessary. The engine has the roles of encoding/decoding multimedia data into MHEG object and interpreting MHEG object to present.

In this paper, we propose the distributed multimedia/hypermedia application development environment based on MHEG standard, MediaADE. It is composed of MHEG engine, database server, and Application Programming Interface(API). In designing database server of client/server environment, ODBC, common database interface, is used in order to solve the discordance of interface between each other database. We also propose the method to solve the discordance of interface between each other network using TCP/IP sockets supported in the most of systems. With the help of our API, programmers can develop applications with easy.

Design of MediaADE

Overview

In this section, we design the MediaADE, an application development environment based on MHEG, the standard of multimedia/hypermedia information representation. MediaADE is made up of three components. One is MHEG engine, another is database server for storing and retrieving MHEG object, and the other is application programming interface(API) for developing application. MediaADE is a client/server environment,
locating MHEG engine and API at client, and database at server. This architecture make it possible for client to maximize calculating ability by interpreting temporal/spatial synchronization information of MHEG object, and for server to minimize overhead. In addition, we locate DBMS and application that interface with database in server to minimize amount of transmission between client and server. Figure 1 represents architecture of MediaADE.

As shown above, MediaADE has three layered architecture. Abstract layer includes MHEG engine and manipulates real multimedia/hypermedia information. MHEG engine manages all of hypermedia objects and plays anchoring and presentation specification in Dexter. It encodes media objects to MHEG objects and transmits them to storage layer. And it decodes MHEG objects transferred from storage layer transmits to presentation application. Storage layer has two components. First, hypermedia database which is comprised database for MHEG objects and file system for media files and a interface module. Second, network interface for transferring media files and MHEG objects on communication and database server. We use relational DBMS and design same interface regardless of the kind of DBMS. API provides functions that maps run-time objects generated in interpreter to physical device by using presentation information, interprets user's interaction and transfers it to MHEG engine.

We implement MediaADE based on the Windows NT. In the authoring application, users can communicates only with API. All functions of MediaADE use NT kernel by using Windows NT's Win32 API. Kernel communicates with real physical devices and makes it possible to use the functions of devices.

MHEG engine

MHEG standard defines coded representation of multimedia/hypermedia information for final-form representation and interchange between multimedia/hypermedia applications in heterogeneous platforms on network. This standard places in a category interaction, multimedia synchronization, real-time presentation, real-time interchange, and final-form representation. Especially, it focus on real-time information transmission and interchange on network[Price, 1993].

Using object-oriented approaches, the standard defines MHEG object for coded representation of multimedia/hypermedia information and that defines MHEG object class for a set of multimedia object with specially consistent structure.

In this paper, we designed the MHEG engine that is composed of MHEG encoder, MHEG decoder, MHEG object handler, and Interpreter. Figure 2 is MHEG engine diagram showing component modules and the flow of MHEG objects through MHEG engine.
(1) ASN formatter generates ASN file from each MHEG object. MHEG engine receives ASN file which is described by ASN.1 notation as input and transmits this to MHEG encoder[ISO8824, ISO8825].

(2) MHEG encoder transmits the MHEG object of byte-stream form converted by ASN.1 encoding rules to communication module. And then communication module stores MHEG object at local database.

(3) In order to process the presentation of MHEG object, presentation interface transmits at first the message(Play MHEG object) for representation to Interpreter. For interpreting this MHEG object, Interpreter transmits the message(Prepare MHEG object) for object request to MHEG object handler.

(4) MHEG object handler loads MHEG object through communication module from local database to prepare specified MHEG object and maintains it by using the structure of tree form. When the preparation of object is completed, MHEG object handler transmits the message(Prepared MHEG object) to Interpreter. In case of that prepared MHEG object includes another MHEG object and refers external media files, MHEG object handler request for these to communication module.

(5) Requested MHEG object by MHEG object handler is converted into internal format and then is loaded into MHEG object handler. External media file is stored directly into memory scope without processing through MHEG engine.

(6) Interpreters interpret link, action and synchronization information from prepared MHEG object. And, Presentation Interface represents presentation object that is related with the interpreted information to user through screen.

(7) In presentation, the events from user may happen. These are entered into Interpreter through Presentation Interface. Interpreter interprets appropriately that and has an influence on MHEG object or presentation.

(8) When Presentation Interface completes the presentation process of a specific MHEG object, Interpreter transmits message for the destruction of MHEG object to MHEG object handler and starts for the presentation of new MHEG object.

Database Server

In this section, we design the database server in client/server environment for the purpose of saving and retrieving MHEG objects. Database server can save and retrieve MHEG objects in database using each MHEG object identifier as a primary key. And database server can send and receive MHEG objects with respond to client's request. We use ODBC common database interface and TCP/IP socket network interface to cope with heterogeneous DBMSs which generally use different network protocol and interface.

Figure 4 depicts the relationship between presentation/authoring client and database server. The vertical arrow, which is labeled "Communication & DB Interface", shows the scope of the communication and database interfaces between clients and server.
When the Presentation Workstation sent query to Database Server, Query Preprocessor in Database Server analyses the query whether it requests MHEG object or media file. If the query request the MHEG object, MHEG Database Manager is called, otherwise media file manager is called. After searching relevant objects or files, MHEG Database Manager and media file manager send these to the Presentation Workstation.

Some classes are used in interchange among applications, ACTION, LINK, CONTENT, and COMPOSITE. And we define the frame class which derived from COMPOSITE class. The frame class is used for representing multimedia/hypermedia data as display unit. So, the frame class includes the all MHEG objects which are played in the same screen.

Application Programming Interface(API)

We design API using object-oriented method in this section. All objects have their own method for creating, destroying, preparing and executing. Created object is translated by MHEG engine, and shown to user by using its own execution method during presentation.

We define classes of multimedia/hypermedia objects, attributes and methods of those classes for supplying efficient API. It is possible, for object-oriented designing.

Object class, in topmost level, is higher class of all other classes. It has only one role, that is inheriting attributes. Session class enables users to connect database, to verify their username and password, to give rights associated level of them. There is only one session object in one application, it must be created after application starts and must be destroyed before application closes. In toolObject class, it is declared that attributes used in channel and template that are used for developing application. Channel and template classes assist author for developing application. Channel maps media to physical devices. Template defines structures of hypermedia for reusing. MhegObject is the highest class of all classes that associate with application programming, storing and transferring. In this class, methods for creating, destroying, preparing and executing are declared. In addition, encoding and decoding method for transferring is also declared. Content class, for media objects, would be played in screen or speaker. Action class defines all behavior resulted from link operation. Actions are transferred in the shape of message, to MHEG engine in order to be interpreted by engine. Methods about message transfer, object construction and destruction are defined in this class.
Link class is executed when users select objects prepared for link operation. Composite class represents a frame. As it is declared recursively and can embed other mhegObject class objects, it manages those objects as a list structure. When a object of this class is executed, it sends messages to its embedded objects.

API functions define as methods of API classes. API functions are separated to creation, preparation, execution and destroy functions. Constructor in C++ language are used for functions associated with creation of objects. When media objects are created, those objects are initialized with handles of their own media files. Preparing functions of objects give attributes associated with created objects. Waiting for starting the execution functions, prepared objects are allocated to channel in order to be shown to users.

Functions which executes objects are different from each other. Static media (i.e. text, still image) end with only one execution, but dynamic media (i.e. sound, video) is not ended until duration because of it's dynamic properties. Because global attributes which are up to various media form are pre-defined in channels, each media objects just have attributes that are used during they are presented. All objects are executed through channels and execution functions of channels are called in order to execute some objects. Function execute() is inherited from mhegObject class, defining presenting method in accordance to media form. Because of composite class object can embed other classes objects in lower level, execute() function is playing these objects by using depth-first search. Content class objects in leaf level are executed immediately. For link class objects, Ready() function is called, and that class objects are waiting for user's interaction. Selecting link object in ready state, action class objects embedded in selected object are executed. For destroy functions, destructor in C++ is used. In case of composite class object, especially, that kind of object must be destroyed after embedded objects are destroyed.

Session class plays a role of bridge between MediaADE and users. Users cannot use API without session. Application sends request to session API for creation of session object. Then API create session object, allocate it to requested application. After that, all requests of application is made through session object. Session object has a mechanism for processing all of generated events or messages, and methods for handling any events that application and MHEG engine generate. In addition, verification process at connection time and handling request for transferring data from MHEG engine are processed by session object. Session object send data to server in order to verify identifier and password. Session object also create virtual channel from client to database server.

Distance Learning using MediaADE

We developed the distance learning application using MediaADE. We used IBM PC compatible as clients.
and Alpha station 1000 as a server. Each client is operated on WindowsNT Workstation 3.5, and server is operated on WindowsNT Server 3.5. We used Oracle 7 for Workgroup Server for WindowsNT as a DBMS.

We constructed the courseware hierarchically. Entire courseware is composed of several groups that have their own subject. Each group is composed of several nodes that have their own concepts. Each node has several frame classes. The frame have all media files and links that would be appeared in the same screen. The group, node, frame classes are all derived from composite class. We mapped media files into the content class, and content class is included in frame class.

We use the MediaADE/Author to generate the media file in authoring clients. MediaADE/Author is the multimedia authoring tool that we had developed. Author generated the media file using MediaADE/Author. Then the media file is converted into ASN file and sent to the communication module. Entire courseware is stored and managed in the server.

Conclusion

In this paper, we design and implement MediaADE as a model of distributed multimedia/Hypermedia applications development environment based on MHEG standard. MediaADE consists of API, MHEG engine, and database server. API is used effectively for developing and presenting. MHEG engine manages and controls these information totally. Database server transmits the encoding information through network and stores them in it. Also it transfers MHEG object when client requires information retrieval.

MediaADE is a client/server environment and it places MHEG engine and applications to client and database to server. This environment makes it possible to minimize overhead of server and to develop a various applications in client site.

MediaADE has the following merits. First, because of its hierarchical structure, connection between heterogeneous system is made easily by changing of interface. Second, MHEG engine is designed as structure in which the internal format after decoding of transmitted MHEG object is mapped into presentation structure of object-oriented method. By using this internal format structure it becomes easier to decode and encode MHEG object at presentation interface, to make dynamic reference to external objects or data files, and to manage sub objects. Third, it is possible to use most database without modification of application program by using common database interface (ODBC). Fourth, interface for application development is a form of object-oriented API and makes it possible to use multimedia object by providing intuitive method to application programmer and user. Fifth, it is possible to reuse multimedia/hypermedia object and useful classes efficiently through object-oriented design method.

The MediaADE would be useful as platform for distributed multimedia/hypermedia applications development on Korea Information Super-Highway.

References

Flexible Link Architectures in Hypermedia Systems

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Abstract: Experience with large hypermedia systems suggests that links, incorporating additional attributes and used in more flexible ways than they are at present, offer a key to the better management of the wealth of data that is accumulating daily in these systems. The topic is introduced by first detailing the significant advantages of systems where the links are bi-directional and not embedded in the documents themselves. We suggest that future systems will benefit from a greater degree of flexibility in link authorisation mechanisms and from a wider variety of link types. Finally we posit new styles of documents that incorporate automatically generated links.

1 Introduction

An overview of links, and the issues related to them, can be found in the report “Links in Hypermedia Systems” [Maurer and Tomek, 1991]. An extensive classification and description is given in [DeRose, 1989]. In the first two sections of this paper we describe how bi-directional links, that are not embedded in the documents themselves, can solve many problems now encountered in systems such as the World-Wide Web (W3). In previous papers we have explained why existing systems such as W3 should be considered “first generation systems” [Lennon and Maurer, 1994, Andrews et al., 1994], and why systems such as Hyper-G [Kappe et al., 1993] may be regarded as “second generation systems”. Two of the reasons given to support this statement are based on the fact that Hyper-G’s links are:

1. Bi-directional (see Section 2)
2. Not embedded in the documents themselves (see Section 3)

We describe how anchors and documents may be redesigned and link attributes used in more flexible ways. In Section 5 we suggest that while the attributes of objects in the hyperbase should be considered context independent, anchors and link types may be user-defined and thus context adaptable in valuable ways. We conclude with an important section that suggests that the advances that we have described will have significant applications in teaching and learning.

2 Bi-directional Links

Links in systems such as Intermedia [Yankelovich et al., 1988] and Hyper-G [Kappe et al., 1993] are bi-directional. Link bi-directionality aids navigation (see next section) and avoids dangling links (see Section 2.2).
2.1 Aiding Navigation

In large hypermedia systems that contain mega-quantities of documents the loss of orientation experienced by users as they travel in the hyperspace can be a very real problem. To help solve this difficulty, an increasing number of modern systems are providing users with dynamic maps. However, only if the links are bi-directional, so that the system is able to follow all incoming links back to their source anchors, can truly meaningful maps be generated. For example, the local maps provided by Hyper-G provide location feedback by displaying all the documents pointing to the user’s current selection as well documents that follow from it [Fenn and Maurer, 1994].

2.2 Avoiding Dangling Links

Of the many reasons for using bi-directional links, the one that is most obvious to all users of the World-Wide Web is the frustration associated with dangling links. If links are uni-directional, and a document is removed, it is difficult to keep track of the source anchors associated with incoming links. Only if the links are bi-directional can the links be traced back to their sources and appropriate action taken (as described in the next section).

In a system such as Hyper-G [Kappe et al., 1993], “link engines” manage all links in separate link databases. The system supports a “scalable architecture for automatic maintenance of referential integrity”, not only at the local server, but across distributed systems, using a “fast, robust, prioritizable flood algorithm” [Kappe, 1995].

3 Non-Imbedded Links

Another condition we consider important for “second generation systems” is that links must not be imbedded in the documents themselves. Having a separate link engine to manage the links has significant consequences. Assuming that the links are bi-directional, then the source anchors can automatically be both de-activated (see next section) and activated (see Section 3.2). Also, only if the links are non-imbedded can links be anchored to “unorthodox” data types (such as movies, 3D graphics, and postscript files), as is achieved in Hyper-G.

3.1 De-activating Anchors Automatically

In large hypermedia systems it is impossible to maintain all anchors manually. Considerable support is needed. If the source anchors reside in the local database they may be made inactive, and un-highlighted, automatically as is done in the Hyper-G system. In a distributed database the link engine can at least send a message (possibly by e-mail) to the system administrator of the originating document. Once the administrator has assessed possible implications of removing the source anchor one click of a mouse should make it inactive.

3.2 Activating Anchors Automatically

It certainly is true that what is not available on the net today may be available tomorrow! Not only are new documents written, but old ones are modified or replaced. This suggests that we need “invisible” anchors in our documents that let the system automatically activate them when a document becomes available. The links may be static or, more interestingly, dynamic – like the links generated using key word attributes such as those discussed in Section 5. This implies that “gatherers” such as the “Harvest” system [Bowman et al., 1994] should support our hypermedia systems.
4 A New Style of Anchor

In most hypermedia systems, textual source anchors are highlighted by displaying them in a contrasting colour, commonly blue or purple. This will become increasingly inappropriate as more systems are built that enable every word to be linked to a dictionary or encyclopedia. The whole document will thus be highlighted. Perhaps only “rare” information should be linked to. For example, nowadays pictures are still comparatively rare so we may wish to list all pictures but no text. Ideally, we should be able to set a preferences option to say what link types are of interest.

In addition, as we will describe in the next section, simple-minded systems, such as those currently in use, deprive the reader of much valuable information.

4.1 Menu Style Anchors

In a document where the links are set up dynamically the anchors may be better displayed using a pull-down menu structure where the top level indicates the number of documents that are linked to (see Figure 1).

![Figure 1: Pull-Down Menu for Automatic Links](image1)

Since one type of link is certainly not enough it would be better still if the anchor gave an indication of the spread of document types, e.g., T(Ext) [6], Graphic [2], or V(ideo) [1] (see Figure 2).

![Figure 2: Anchor Using Scope Definition and Keywords](image2)

The anchor menus may (at least in theory!) be nested as shown in Figure 3.

![Figure 3: Nested Anchors](image3)

4.2 Support For Document Versioning

Versioning is a most important part of any hypermedia system – particularly for computer supported collaborative work. Usually the system returns the latest version of a document; but there are times when this is not what we want. Our ideal system would use extended anchor types to further help the user. For example, the anchor could indicate if older versions do exist. Or, in a dynamic anchoring system, there could also be an indicator that shows we are accessing an old version where a new version now exists. It would just take a small icon in the corner of the anchor, to indicate such valuable information.
5 Link Attributes

In the discussion that follows we assume that the links in the link database have a well defined set of attributes. Hyper-G, for example, has implemented a wide range of link attributes that include:

- **Author.** The author/owner of the link.
- **Title.** A search scope may be included in the attribute.
- **Rights.** Only the specified people can traverse the anchor (see below).
- **TimeModified.** This is updated automatically if the link is modified after creation.
- **Description.** Additional information.
- **TimeOpen.** The time that the anchor becomes visible to anyone other than the author – as determined by the Rights attribute.
- **TimeExpire.** The reverse of TimeOpen, i.e., the time the anchor ceases to be visible to anyone but the author.
- **Keyword.** This attribute can be attached to anchors as many times as needed. It is a means of attaching additional words that can be searched on and used to identify the anchor. This is an important field that we shall use as described in Section 6.

With attributes such as these we are able to collect statistics such as how many people have accessed any particular document. We may be able to make better use of the powerful query programs that are available. Although, as noted by Conklin, “there is some controversy over the relative merits of keyword retrieval as opposed to full text search” [Conklin, 1987], the better option may well be scope-defined full-text searches, used in conjunction with the customised documents described in Section 7.

Link authorisation systems should support the following specifications: no links are visible, all links are visible, some links are visible only to some people, i.e., to a group of people. The last option, that of group authorisation, is of considerable interest, as we describe Section 7 and Section 8. It will enable us to impose personal views on works for our own or other peoples’ viewing. We can also, most importantly, make annotations that are visible only to us. It is of significance we may need to create links, with authors’ permission, in documents that we do not have write privileges in.

6 User-Defined Link Types

Nelson, using a library paradigm, was one of the first people to suggest that links could be typed [Nelson, 1987]. In an electronic library system a link may be of type: reference, abstract, annotation, or footnote.

Users may define their own link types by, for example, implementing them as a special case of link attributes. Halaz in “Reflections on Notecards: Seven Issues for the Next Generation of Hypermedia Systems” describes the type of a link as a “user-chosen label specifying the nature of the relationship being represented” [Halasz, 1988]. The words “user-chosen” are of significance. It is important to note that while, in a well designed hypermedia system, the data objects and their attributes can be thought of as context independent (i.e., individual chunks of text, pictures, video clips, etc., with attributes such as author, title, date), anchors and their associated attributes can be created to flexibly fit the context, i.e., made context dependent. In fact, in extreme cases what is true in one context may be false in another. For example, in a recent debate among environmentally conscious city councillors a purple house was classified as “not acceptable” in a green setting but “acceptable” in a blue (sea-side) setting! In Section 7 we discuss further the use of user-defined links to customise hypermedia documents.

Users can define the link attributes to suit their current needs. A suggested list of WWW link relationships has been posted on the Net [Net1995s, 1995]. The list includes, among other relations, the following: Annotation, Reply, Precedes, Supersedes, History, Owns, Approves, Supports, Refutes, and Interested.

Hyper-G adheres to the same philosophy as Intermedia, where webs allow “one or more users to work within their own context undistracted by blocks and links created by others sharing the same computing resources” [Yankelovich et al., 1988]. For example, we should be able to browse all documents, within a certain scope, that have links to them produced by a specific author, and containing certain keywords. As we suggest in Section 7, course material from a wide variety of sources can be packaged in this way.

Associated with each link type, there may be a second field which is a weighting. For example, the safety officer in a company may define links of type “cause” (or “effect”) to the collection of “accident scenarios”. There could then also be “risk”, “probability”, or “uncertainty” weightings.
The fact that multiple users can simultaneously use the same data space provides users with a way of annotating, as well as customising other authors’ documents, as we describe in the next section.

7 Customising Documents

The facility for multiple users to add links to other authors’ work is an important one. Back in the 1960s Ted Nelson had a vision of a world-wide library that lets users author and link “chunks” of multimedia material [Nelson, 1987]. By defining links for groups of readers we are able to customise documents in a way that at last lives up to Nelson’s dream.

![Figure 4: Customisation of Documents](image)

How the copyright question for such authoring is handled is, of course, an open one. The question of advertising is also an interesting one. One suggestion is that publishers may supply copies for distribution centres, or to institutions such as universities, for a fee on a “number of copies” basis, i.e., if an unacceptable number of users are “locked” out of being able to access a certain journal, then the institution will have to buy another license.

8 A New Style of Document

Using webs consisting of customised documents as described above and in Section 6 may change the style of documents dramatically. An increasing number of documents will consist of just one or more anchors displayed on a page that has little more than a few lines of text and perhaps a colourful graphic.

![Figure 5: A New Style of Document](image)

Also, we predict that we may see more automatically generated documents. We are at present working on automatically formatting documents where the URLs have been recovered by search queries. These documents will have also have form-like layouts. Shortcuts such as these will undoubtedly influence document style. We note that the students will have a mass of material available to them in electronic form. Complete digital libraries are becoming available on line.
[Maurer and Lennon, 1995, Marchionini and Maurer, 1995b, Marchionini and Maurer, 1995a]. In particular, students can access electronic journals such as the Journal of Universal Computer Science [Calude et al., 1994, Maurer and Schmaranz, 1994, JUCS, 1994]. Some of the anchors are controlled by “TimeOpen” and “TimeExpire” attributes. Webs may consist of annotated material as well as dynamic anchors to archived material (past lectures), recommended reading lists, announcements, etc. Thus, each course can be tailored to the particular group of students much more readily than has been done in the past.

9 Conclusion

In this paper we underlined the advantages of hypermedia systems where link engines support link bidirectionality and non-embeddedness. We described extended forms of anchors and user-defined link types. In particular, in the case of automatically generated links, the anchors can provide users with additional information such as the number and type of documents that lie within a certain scope. We described how new styles of document may evolve using webs of customised sets of data objects, user-defined links, and attributes such as Group, TimeOpen and TimeExpire. Finally, we apply the new ideas to teaching and learning, showing how they may provide a greater degree of flexibility than is currently available.

References


Adaptive Interaction through WWW

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Abstract: The advent of graphical browsers has transformed the World-Wide Web from a tool for scientists to an information and recreation source for millions of people. The Web seems a natural vehicle for distance learning activities, yet is of limited effectiveness for that purpose due to extremely limited abilities to modify the format, pace and sequence of material presented in response to a student's preferences or performance. This paper discusses issues related to providing Adaptive Interaction and Instruction using the World-Wide Web. We include a brief survey of human-computer interaction topics relevant to the Web, describe the mechanism available to effect adaptive interaction, present a design model for an adaptive education system, and close with a summary of our experience with one such system for introductory programming and a few suggestions for future research activities.

Introduction

In the past year the World-Wide Web (WWW) has exploded in the national consciousness. Its technology, originally developed by scientists to exchange visual and audio information as well as text, seemed the solution for translating techno-speak into something people without a technical background could understand. With a click of the mouse, users could browse through colorful menus that offered everything from company brochures to tutorials of Home Page construction. It simplifies one thing: the way of communication.

Given years of interest in distance education and the wide accessibility to the Web currently available, it is natural to consider using the WWW for instructional delivery. Web documents, however, are typically designed for one-way communication, and the "stateless" nature of Web connections makes it difficult to adapt the presentation of instructional material to the student. There are no simple mechanisms to provide the level of interaction and participation available in systems such as New York University's Virtual College [Byte 95].

With these motivations, we are investigating the design of a system for Adaptive Interaction and Instruction on the WWW. Our project is focused on developing an integrated toolkit based on the WWW for adaptive tutorials and testing or distance learning, corporate training, and curriculum enrichment. The initial problem domain is introductory programming in C++.

The remainder of this paper discusses human-computer interaction in the context of the WWW, factors relevant to delivering computer-based instruction over the WWW, and a model of components for an adaptive instructional system on the Web.

Human-Computer Interaction and the WWW

Mechanisms for Human-Computer Interaction (HCI) have undergone amazing changes in the past 20 years, from command-oriented systems that placed all the burden of correct communication on the end user's ability to
remember commands, to the direct manipulation systems common today, which place much of what is needed to
control that communication "in the world" of the user interface [Norman 90], and allow even inexperienced
users to make effective use of computers.

However, by comparison with human-human interaction, the current state of human-computer interaction is
relatively spartan. Among themselves, humans use a wonderfully rich set of media: the words and tones of
spoken language, gestures, facial expressions, "body language," drawings and other audio-visual aids. Human-
computer interaction is usually limited to typed words, graphical displays, and menu selections via pointing
devices. Part of the great interest in multimedia is the intuitive belief that making a wider range of media
available to the participants in a human-computer dialog will significantly enhance that dialog.

Hypermedia adds another dimension to a multimedia dialog. The author of a hypermedia document not only
presents material in the document, but also adds "links" to related information within the document or in
external documents. The destination of a link may be text, graphics, imagery, audio, or video material, which in
turn can contain links to other information, and so on. The author uses a particular medium to explain a
particular concept based on the relationship of the semantics, dynamic nature, and information density of the
medium to the nature of the concept. The path taken through the maze of interconnections, and sometimes the
choice of the medium used to present information, is under the control of the human end user. The WWW is an
example of a distributed hypermedia system.

Hypermedia is structured and non-linear in contrast to conventional unstructured and linear text, making it a
good way to package information for efficient information retrieval. It is useful for some forms of interactivity,
but because of its fragmented nature, it may not be the ideal medium to form the core of teaching materials. A
learner-centered rhetoric is possible for hypermedia based on its malleability and its use in a supplementary role
within the context of a more general instructional form. Web-based hypermedia offers considerable potential
for education. Moreover, malleability allows us to offer multiple perspectives on a particular domain. It is
possible to use hypermedia to present, and then re-present, ideas in ways that are difficult to achieve in regular
text.

Communication and Interaction

We make a distinction between communication and true interaction [Nass and Steuer 93]. Communication
involves the transfer of information from a source to a recipient. True interaction requires communication in
two directions, with the information provided by each party influencing the actions of the other. Greater degrees
of interaction are achieved by using more of the historical context of the dialog to influence actions. User
interfaces which implement true interaction are referred to as adaptive interfaces (they adapt their characteristics
to those of the user).

There are only a few moderately interactive experiences available on the WWW, typically games that support
simple interactions not nearly as satisfying as games running on stand-alone computers. The argument is
commonly made that the great individual control provided by hypermedia is enough to lead to a more satisfying
user experience.

Our experience with student use of WWW information is that students demonstrate a great range of enthusiasm
and persistence in seeking materials, and the poorer students (those most in need of supplemental enrichment)
are the least effective at ferreting out the necessary information. This implies that simply providing a
hypermedia enrichment environment may lead to an enjoyable experience but not necessarily to successful
learning [Palmiter and Elkerton 91]. We believe the key to successful learning is an adaptive hypermedia
environment which preserves most of the freedom of movement through the material while providing guidance
on topic selection and, optimally, making choices on the set of media available to the student based on past
learning experiences.

Relation to Web-Based Instruction
This mimics human-human communication, in which there is usually a significant amount of adaptation of communication style and content for both participants, in an attempt to maximize the exchange of information. This is especially true in student-teacher communication, where the teacher dynamically modifies both the style of presentation and even the material being presented in response to the student's understanding.

In computer-assisted instruction (CAI), researchers have sought to develop instructional systems that mimicked this adaptive behavior since the early 70s. [Wenger 87] provides an excellent overview of those early systems, and both [Polson and Richardson 88] and [Self 88] provide snapshots of recent active research projects. In general, these intelligent tutoring systems attempt to build a model of the student, and use that model in conjunction with knowledge about the domain of instruction and instructional strategies to modify the order of presentation of material, selection of hints and corrections, and style of interaction with the student.

As previously mentioned, this is difficult to do given the philosophy of the WWW, since the system never knows the path by which a user has arrived at a particular place in a hypermedia document. In addition, the hypermedia document should work with all of the various Web browsers available, so the enrichment materials cannot demand modifications to those standard browsers. In an educational setting, particularly one in which students are formally registered for a particular sequence of study, it is possible to provide constraints on materials and adapt the interaction to past user performance.

Common-Gateway Interface

The mechanisms that make this possible are the Common-Gateway Interface (CGI) and interactive forms. As shown in [Fig. 1], forms are transmitted from the HTML server (the HTTP daemon) to the WWW browser and submitted to the server once completed. Each form is associated with a particular CGI program, which is activated by the Web server when the form is received. The CGI has access to the data populating the form and has full freedom to manipulate it in any way desired. In particular, the CGI can output to the HTTP daemon text which represents another page of information to be transmitted to the WWW browser for review by the student. For purposes of Web-based instruction, then, forms are the mechanism for returning particular response information from the student and the CGI provides the programmatic mechanisms to record that input, relate it to previous inputs, and to select a particular set of choices sent back to the student for subsequent hypermedia browsing. That is, to control the presentation of material based on past dialog history.

Thus the structure for WWW-based education becomes a hypermedia document with periodic evaluation activities. The evaluation exercises are presented as forms, which are completed by the student and submitted
by sending them to the server for evaluation. This CGI/forms combination allows us to offer a variety of evaluation methods:

- True/false or multiple-choice questions
- Matching items with clickable map or graphic
- Short-answer questions
- Simple essay questions and, most importantly for our problem domain
- Perform procedures and evaluate the results

One of the most attractive characteristics of the WWW is that it allows rapid changes to and updating of content, as opposed to the stable homogeneous materials typically used in education. It is important that the evaluation mechanisms not interfere with that dynamism. Thus a major focus of our project is to develop toolkits which allow a document author to design and include evaluation and response mechanisms relatively easily.

System Design Model

It has been observed [Polson and Richardson 88, Self 88, Wenger 87] that the primary objective of an Intelligent Tutoring System (ITS) is to develop an effective teaching and learning environment. Most papers in the field of Computer-Aided Instruction introduce ITS by giving simple system descriptions and examples. A more general description is: an ITS is a system composed of four modules (expert module, instructor module, interface module and student module) working cooperatively to effect desired learning outcomes [Fig. 2]. The modules can be briefly described as:

- The expert module is a subject specialist or can be treated as a knowledge-base for the instruction. This module provides the curriculum as well as low-level teaching methods.
- The instructor module conveys the subject material to the learners in different ways based on student requests and responses.
- The interface module provides the interaction channels between the teacher and the students.
- The student module records students' basic information on the progress in learning, coverage of material, and preferences.

In our implementation, all four of these modules are located on the HTTP server machine and are invoked by the CGI programs as needed to modulate the interaction with the student. The browser machine with which the student is actually viewing the instructional materials simply displays the WWW hypermedia and transmits the forms filled in by the student back to the server machine and the CGI. The remainder of this section discusses each of the modules in more detail.

Expert Module

The expert module's knowledge of the subject area is encompassed in a set of HTML files that actually transmit the material to the student. The micro level instructional techniques are incorporated in the way in which the material is explained, as well as the particular media chosen to present a particular topic.

Instructor Module

In a traditional WWW-based system, control of the order of presentation of topics is strictly in the student's hands. But it is still possible to modify the student/system interaction to provide diagnostic hints and to somewhat modify the form of presentation. The instructor module varies the level and medium of the HTML documents actually presented to the student, using the information recorded by the student module. Currently, this is effected by connecting hypermedia links, from one major topic to another, to a form. Transmission of the form invokes the instructor module to select the actual HTML page transmitted to the browser. Alternative paths for presentation of particular topics are represented as a directed graph with labeled links.

The objective of this modification, of course, is to maximize the knowledge gain by the student. To do this we must address issues of both student learning style and teaching methodology. [Dunn, et al. 89] describe learning...
style as the manner in which various elements of four basic stimuli affect a person's ability to absorb and retain information, values, facts, or concepts. The four stimuli are environmental, emotional, sociological, and physical.

- The four environmental elements are: sound, light, temperature, and design.
- The four emotional elements consist of motivation, persistence, responsibility, and structure.
- The six sociological needs that affect learning are believed to be peers, self, pair, team, adult, or a combination.
- The four physical elements are perceptual, intake, time, and mobility.

Of these elements, there is little adaptive interaction can do to modify the environmental and emotional stimuli, although the self-control and stimulation available through the WWW are often cited as enhancing factors for students' motivation and persistence. Similarly, there is little interaction can do about sociological stimuli in a 1-to-1 dialog, although there may be some aspects of a team approach that can be addressed on the Web (see the last section). Our efforts at adapting the interaction to the student will primarily address the physical stimuli through changes of medium, level of content, and pace.

[Dunn, et al. 89] also cite a study of teaching methodology in which students learned more and evaluated their teachers positively when the teaching methods were matched to the learner's cognitive styles. We are focusing on three measures to encourage optimal facilitation of learning:

- Adaptive: matching the teaching method to the learner's cognitive style;
- Progressive: incorporating classroom problem solving training into all curricula; and
- Interactive: the use of interacting methods.

Interface Module

Since we insist that our materials function with standard WWW browsers, our interface module is restricted to the features provided by standard Web servers and browsers.

![Diagram of Adaptive Interaction](image)

Figure 3: Adaptive Interaction.

Student Module

The student module records information about the student's current and previous interactions with the system. This student model information provides the "state" data needed to allow adaptive interaction, see [Fig. 3]. As indicated above, these data include performance on evaluation activities and paths selected at major branch points between topics (essentially, information about the level of material previously seen).

Following [Eberts 94], we categorize the approaches to developing a student model as:

- Topic marking: the system keeps track of the information presented to the student relative to a syllabus of topics to be covered.
- Context models: the extent of the student's knowledge is inferred from the dialog or from answers to direct questions to the student.
- Bugs: the student's knowledge is characterized in terms of the misconceptions demonstrated about the subject.
- Overlay: the student's knowledge is defined in comparison to the knowledge representation of a subject
• Generative modeling: the plans used by the student to solve problems are used to build a model of knowledge about the domain of instruction.

Our approach combines the topic marking, bug, and generative approaches to student modeling. Selection of appropriate data to allow effective modeling, and the use of that data to correctly modify the interaction for maximum learning is a significant topic of our research.

Current Status and Experience

Adaptive Interactive Tutorial System is an experimental prototype which we use to get practical experience with our ideas. As of now (Spring 1996), the most significant part of the development is the interface module with simple student modeling which relied on the existing CGI and Java Applet mechanisms. The prototype will be implemented completely in CGI and Java Applets to all the interactive facilities. In order to illustrate our approach we give an abstract model to describe the association of different components.

Let $M$ and $M'$ be the set of materials and methods for teaching. We use $H$ to represent a set of HTML interactive forms. We have a group of students enrolled in the class, we identify them as $U$, user, and $S$, student. There is an one-to-one mapping between User and Student. We will keep track of the profile $s_0$ of each student to monitor her/his demands and progress. The interactive module will perform at least three functions: identification, delivery, and update.

$$P : U \rightarrow S$$

(1) says when the users login, the system will identify them and retrieve the profile from $S$. According to the student profile, (2) indicates that the system will adopt material and methods to deliver an interactive form. This is the most critical part of our project. After a session of interaction, (3) shows that the system will update the student profile. Our prototype has completed the functionalities of (1) and (3).

Additional Research Areas

Perhaps the most intriguing future development is the possibility of downloadable "applets" that can be run on the browser machine and offer substantially greater opportunity for customization of the user interface provided by the browser based on the student model data collected by the student module.

This approach may also offer an opportunity to address the team aspect of learning, through group discussion possibilities similar to the on-line virtual group provided by the Sociable Web [Donath 95]. This project modifies the Web browser and server to provide a number of social and collaboration features on special Sociable Web pages. It shows who else is on the pages and allows the user to strike up conversations or to join in ongoing discussion. If such capabilities could be provided without modifying the browser or server, students might be able to use each other as on-line tutors to expand on the instruction provided by the hypermedia.

References


Abstract: ATM (Asynchronous Transfer Mode) is a high speed, high performance, multiplexing and switching technology that has important implications for distance learning. With its unique ability for transmitting multiple types of broadband communications traffic in a seamless integrated environment, ATM can support networked multimedia, virtual reality, and interactive video applications. Despite ATM’s potential for accommodating innovative telelearning paradigms, debate persists in the academic community about whether the time is right to invest in ATM technology. This paper examines ATM capabilities, merits, and limitations. Representative ATM projects in the distance education environment are described. Challenges associated with ATM use in the educational setting are explored. Strategies facilitating ATM deployment for instructional delivery and enrichment are delineated.

Introduction

Graduate students in library and information science at San Jose State University, San Francisco University, and California State University, Fullerton, are about to participate in an innovative teleducation master’s program that includes collaborative videoconferencing and simultaneous access to distributed software and multimedia resources. Youngsters at the Tech Museum of Innovation in San Jose will soon take part in media-rich telescience activities that feature real time video and voice exchanges with experts at the Monterey Bay Aquarium. Sponsored by CalREN (California Research and Education Network), these projects illustrate the projected role of ATM (Asynchronous Transfer Mode) networks in facilitating imaginative and creative instruction, curricular development, and new approaches to teaching and learning [http://www.pacbell.com/SuperHi/CalREN/Projects].

ATM is a high bandwidth, low delay, connection-oriented technology that offers integrated circuit and packet-switching services [Kim & Wang 1995]. With its promise of universal connectivity and support for networked multimedia, virtual reality, and interactive video applications, ATM is viewed as a key enabler for distance education.

Although ATM is uniquely suited for high speed networks, debate persists in academic circles about whether the time is right to migrate to ATM technology. An analysis of my case study research demonstrates various concerns among those investigating ATM implementation. Potential barriers include high costs, immaturity of ATM standards, limited ATM geographical availability, lack of integrated network management options, and insufficient data on the effectiveness of ATM applications and quality of service offerings.

Questions that are critical to any consideration of ATM as a networking solution for supporting distance learning include the following:

- What are the basic features of ATM?
- How is ATM presently used? What are projected applications?
- What are key advantages and drawbacks associated with ATM implementation?

This paper addresses these questions, examines the capabilities of ATM in the distance education environment, and delineates approaches for ATM deployment.

Basic Features of ATM

ATM is characterized by its transmission efficiency and high speed in providing bandwidth-on-demand for multiple types of network traffic. ATM works from 155-Mbps (OC-3) to 622-Mbps (OC-12) and is expected to reach 10-Gbps. (OC-192). Optionally, ATM also operates at 45-Mbps and 25-Mbps.

At the core of ATM technology is a standard fixed sized 53-byte cell consisting of a 5-byte header or addressing mechanism and a 48-byte payload or information field. Since the ATM cell length is constant and
buffer memory size is always known for each cell, the ATM platform provides an ideal way for reliably switching different types of traffic from source to destination.

The terms ATM, cell relay, and cell switching are used interchangeably. ATM is emerging as the technology of choice for next generation LANs (local area networks), MANs (metropolitan area networks), WANs (wide area networks), and integrated networked environments. ATM can work over such physical media as copper and optical fiber and is being adapted by Freebird Communications Ltd. (Haydock, U.K.) for wireless transmission. Standards for ATM are defined by the International Telecommunications Union-Telecommunications sector (ITU-T) and the ATM Forum, an international consortium with a membership that includes service providers, equipment manufacturers, and universities.

Communications Significance

Educational applications such as interactive video-on-demand, digital image transfer, remote access to multimedia electronic libraries, videoconferencing, and electronic publishing contribute to congestion in traditional computer communications networks [Littman 1995a]. First generation LANs support high bursty data rates over short distances but are limited in sustaining delivery of distance learning classes with two-way video applications and interactive multimedia instruction. Although second generation LANs support 100-Mbps on optical fiber, these FDDI (Fiber Data Distributed Interface) networks are used primarily for data.

Distinguished by its capability for handling audio, full motion video, data, and images on the same network, ATM is designed as a universal transparent communications solution. With its capacity for supporting bandwidth intensive operations and complex network configurations, ATM is expected to revolutionize instructional delivery.

Current and Projected ATM Applications

Representative projects that exploit and evaluate ATM capabilities are reflected in the material that follows. These projects indicate the range of ATM functionality.

Operational since August, 1994, the North Carolina Information Highway (NCIH) is the first major public deployment of ATM technology [Patterson & Smith 1994]. NCIH participants such as Duke University, East Carolina University, and the University of North Carolina use the network for distance education and collaborative research. Gary Munn [personal communication, June 8, 1995], Sales Engineering Manager with Fujitsu Network Switching, observed: "The beauty about ATM use in the NCIH is its flexibility."

Bruce Johnson [personal communication, September 1, 1995], lead network engineer at Cornell University, stated that Cornell University is participating in NYNet with such sites as Rome Laboratory, Syracuse University, the State University of New York at Stony Brook, Brookhaven National Laboratory, and Columbia University. NYNet is an ATM testbed for exploring multimedia communications and supercomputing capabilities in New York State. Projected applications include electronic publishing, electronic library services, digital imaging, multimedia conferencing, and the use of distributed virtual reality applications in kindergarten through twelfth grades.

Johnson added that ATM is also being tested in a "meta network" called vBNS (very-high-speed Backbone Network Service). Developed by the National Science Foundation, this research network is designed to provide data on network performance that will be useful for future Internet development [http://www.vbns.net].

At Indiana University (IU), ATM capabilities are under evaluation in a multi-campus technology project. Doug Pearson [personal communication, August 31, 1995], network analyst and project manager with IU’s ATM Group, noted: “Since ATM is not yet fully developed, we are not ready to use ATM as our campus backbone. We are, however, interested in examining ATM capabilities for supporting workgroup solutions.” Pearson explained: “One such application involves digitizing IU’s music collection as a basis for creating a state-of-the-art music library.” IU is also assessing ATM’s videoconferencing potential with point-to-point delivery of courses to teachers, librarians, and media specialists at campuses in Bloomington and Indianapolis. When fully operational, this network will support voice, video, and data communications from all of the university’s multi-campus distance learning classrooms, both point-to-point and multipoint connections, and interoperability with other integrated distance learning networks.

A project of the Oregon Joint Graduate Schools of Engineering, NERO (Network for Engineering and Research in Oregon) is testing the feasibility of using ATM as the basic network technology for wide area links among participating institutions [http://www.nero.net/]. Future applications include delivery of advanced degree programs and colloquia and seminars to faculty and engineers.
These projects demonstrate widespread professional interest in implementing ATM supported telelearning applications. In a university setting, ATM enables the design of a technology mediated multimedia environment that can accommodate individual learning styles, skills, and competencies [Littman 1995b]. ATM deployment can culminate in the development of a collaborative educational network infrastructure that enables virtual field trips, telementoring, innovative courseware and training paradigms for curricular delivery, and the creation of global classrooms. The learning experience can be enhanced by providing worldwide access to such instructional tools as high resolution images and multimedia data from virtual electronic libraries.

ATM Advantages

ATM provides a seamless integrated environment that maximizes resource sharing and productivity. ATM technology co-exists with existing networks and can be implemented incrementally depending on application requirements. Designed as a multi-service platform, ATM also supports migration from other fast packet services including Switched Multimegabit Data Service (SMDS) and frame relay. Well suited to backbone applications, ATM expedites enterprise networking, LAN/WAN integration, and worldwide interoperability.

Distinguished by its capability for rapid transfer of voice, data, and video and facilitation of high performance multimedia applications, ATM can lead to innovations in the instructional curriculum. ATM networks can support real-time interaction in virtual collaborative learning environments; delivery of teleducation courses, thereby eliminating the need for students or instructors to travel to remote sites; flexible teaching schedules; and requirements of diverse student populations such as degree-seeking working professionals.

ATM Limitations

Despite the promise of ATM for serving as the foundation for future high speed computer communications networks, there are barriers to ATM deployment. These include high costs for equipment, communications and operations; expenditures for migration to the new technology; interoperability difficulties; and lack of off-the-shelf solutions.

ATM is such a new technology that standards and testing methods are still under development. The National Institute of Standards and Technology is currently designing a suite of tests that include queuing models and simulation for assessing ATM operations, protocols, and standards conformance [http://isdn.ncsl.nist.gov/]. ATDnet (Advanced Technology Demonstration Network) is a high performance networking testbed in the Washington, D.C. area for examining ATM services over optical fiber at 2.5-Gbps. (OC-48) [http://www.atd.net/atdnet.html]. These efforts are expected to lead to improved ATM performance and facilitate widespread ATM implementation.

Bill Jones [personal communication, June 8, 1995], network analyst at Virginia Commonwealth University (VCU), commented that a crucial factor in ATM assessment is clearly understanding technical specifications of ATM products. Jones noted: “Some ATM products won't work on single mode optical fiber while other products won't work at all. In investing in ATM, you must make sure the product is in actual use and not vaporware.”

ATM switches provide the underlying physical structure for the network configuration. ATM switch capability in sustaining end-to-end network performance contributes to the importance of this emerging technology. Yet, some ATM switches comply to the ATM Forum’s UNI (User-to-Network Interface) version 3.0 while others conform to the newly emerging version 4.0, thereby leading to differences in functions enabled.

Vernon Williams [personal communication, June 14, 1995], lead systems engineer and network architect with communications and network services at VCU, stated: "A serious limitation associated with ATM is the lack of comprehensive standards and cross vendor support. At this point, you are virtually required to use a single vendor to supply all of your ATM equipment in order to achieve functionality."

Bruce Leonard [personal communication, August 31, 1995], network engineer at the University of Pittsburgh, related: “While we are interested in ATM, we prefer to take a wait and see approach. Because there are so few vendors in the field, current ATM costs are extremely expensive. We also are concerned about interoperability problems with equipment from different vendors. Clearly, in the future, once standards are more fully developed ATM will be extremely attractive.”

With its capacity for high speed transmission, ATM appears to be the ideal solution for multimedia delivery. However, another weakness of ATM is its presently limited capacity for carrying voice traffic. Standards for switching voice over ATM networks are not expected to be adopted until 1997.
According to Munn [personal communication, June 8, 1995], with ATM’s assurance of instant connections, individuals are under the impression that ATM technology supporting instructional delivery will be as easy to use as making a telephone call. Munn observed: "In reality, there is a steep learning curve.” Factors that can contribute to user acceptance include an understanding of technology fundamentals, acceptance of agreed upon standards, lowered costs, and planning guidelines.

ATM in Action

Created for deployment of broadband communications networks, ATM is making the transition from theory to practical use. Generally, most vendors provide similar capabilities including constant bit rate and variable bit rate support and 155-Mbps access rates [Malone 1995]. Despite ATM's potential for facilitating instructional delivery, research, collaboration, and global information exchange, an analysis of the interviews and discussions I have had with university leadership indicates a reluctance to implement ATM fully until the technology becomes more mature and affordable. Among considerations associated with ATM implementation are cost and design, the need for upgrading existing legacy systems, the proliferation of vendor-proprietary solutions, and provision of staff education and training. Typically, the migration to an ATM environment is an evolutionary one characterized initially by piloting test networks for specific applications.

The University of Minnesota Medical School links metropolitan hospitals over an ATM network for delivering instruction to medical residents and training to physicians in the field. Will Murray [personal communication, June 14, 1995], senior systems programmer with university networking services at the University of Minnesota, noted: "In terms of campus activities, we have had success in using ATM for pilot projects involving such high bandwidth implementations as 3-D molecular modeling. We will seriously look at ATM for our campus backbone network once the standards are more clearly defined and products are more readily available.”

Michael Scott [personal communication, June 10, 1995], network analyst at the University of California at Irvine, said: "Currently, we use experimental ATM to support research projects in the fields of medicine, biology, and computer science. We expect to deploy an ATM campus-wide network in the future, after the technology comes out of its infancy.” Sara Fischer [personal communication, September 2, 1995], Associate Director of Advanced Technologies for the University of Chicago, indicated: “Although there are no immediate plans for wide scale ATM deployment on the University of Chicago campus, the university is participating in an ATM pilot project with Fermilab and the Argonne National Laboratory in support of high energy physics research data exchange.”

There is no absolute assurance that ATM will offer trouble free network performance. Lockheed Martin is currently evaluating the effectiveness of ATM based security mechanisms for safeguarding proprietary and classified data and testing ATM capabilities in accommodating bandwidth demand as the number of participants in a war game simulation increase in number from between ten and 100 players to between 1,000 and 10,000 players [http://www.ca.sandia.gov/repalmer/CalREN.html].

With the tremendous transmission speeds of ATM, problems associated with traffic flow can occur before traditional network management tools can detect them [Malone 1995]. Karen Fromkes [personal communication, August 31,1995], Assistant Director for Network Systems at Cornell University, related that pilot ATM tests are underway on the Cornell campus for examining ATM’s ability to guarantee a given quality of service.

Rory McGreal [personal communication, September 1, 1995], Executive Director of TeleEducation New Brunswick, said: “Our ATM installation is among the first planned deployments in Canada. We expect to link four universities, two community colleges, and a residential suburb to our ATM infrastructure.” McGreal pointed out: “Theoretically, ATM is fine. In actuality, problems with implementation persist. For instance, equipment we thought would be readily available is still in a test mode.”

ATM technical issues are challenging. The pedagogical considerations associated with the educational use of ATM are multifaceted. McGreal noted that upon achieving full functionality TeleEducation New Brunswick will support ATM based distance learning. According to McGreal [personal communication, September 1, 1995], “Our major challenge as educators will be designing course content that takes advantage of ATM’s high bandwidth.”

ATM usage also poses additional important pedagogical questions in relationship to distance education. What are the implications of ATM paradigms for the academic community? Should an ATM enabled virtual university replace a physical campus site? What are the advantages and drawbacks of ATM implemented distance education sessions in comparison to traditional classes? What role will there be for direct human interaction in an ATM generated learning environment?
Planning the transition to ATM requires clearly defining goals to ensure that expectations concerning ATM are realistic, overcome resistance to change, and address technical and pedagogical concerns.

Planning Guidelines

With ATM, we can create dynamic distance education environments. Yet the ATM infrastructure is complex. How can we take advantage of ATM networking capabilities? What are key strategies for ensuring that ATM contributes to effective educational outcomes? Is the cost/benefit relationship associated with ATM implementation strong enough to warrant an investment of university funding? Does the technology satisfy institutional requirements? Will users really benefit from ATM deployment?

In evaluating the suitability of ATM for the university setting, the need for ATM and its priority with respect to other computer communications requirements should be addressed initially. Instructional applications selected for deployment should cost justify the expense of ATM investment.

Williams [personal communication, June 14, 1995] recommended a phased approach. "At VCU, we are exploring the implementation of ATM supported multimedia classrooms at libraries on our medical campus and academic campus. Although ATM will play a key role in distance education, it will be pricey in the near term." Williams emphasized the significance of questioning vendors about the capabilities of their products. He remarked: "It is important to be well versed in ATM technology and to compare services and offerings from several vendors. Don't stop your investigation after talking to the first vendor."

Questions that can assist in evaluating ATM viability include the following:

- What types of instructional applications can be enabled by ATM now and in the future?
- Are expectations concerning ATM educational benefits reasonable?
- How can ATM be integrated into the existing campus network infrastructure in support of distance learning?

A feasibility study can establish with greater accuracy the likely success of ATM implementation. Questions that can be used in conducting the feasibility study include the following:

- What are the total estimated expenditures such as charges for hardware, software, and communications for ATM implementation?
- Are university traffic requirements suitable for ATM deployment?
- What security mechanisms are available?
- How can ATM facilitate interoperability across diverse computing platforms?
- Are ATM products from different vendors compatible?
- Is the time right for ATM deployment?

On the basis of the feasibility study, a decision can be made to implement ATM or discontinue the investigation. A report reflecting inputs from the feasibility study should include a description of network goals and application objectives; risk issues that need resolution; equipment and communications specifications; initial capital outlay; recurring expenses for operations, maintenance, and support; and training requirements.

If the decision is made to go forward with ATM deployment, a request for proposal (RFP) can be developed for distribution. ATM carriers and service providers include AT&T, Bell South, GTE, MCI, Nynex, and Sprint. Vendors active in the field include FORE Systems, Bay Networks, Newbridge, 3M, and Cabletron.

Another option for ATM deployment is outsourcing. Outsourcing involves contracting an outside vendor or communications carrier to implement an ATM solution. For instance, Ameritech designs an ATM based network to accommodate institutional requirements and also provides ATM equipment and communications services at a set lease fee, thereby eliminating the need to make a capital investment. In addition to minimizing financial risk, outsourcing protects the user against technological obsolescence. Indiana University, for example, has established a corporate partnership with Ameritech in development of the university’s ATM network.

Cornell University is examining outsourcing possibilities as well. Fromkes [personal communication, August 31, 1995] remarked: “Through merging video, voice, and data, ATM can be a world class network. Cornell University plans to use ATM for its campus backbone and extend ATM to the desktop for support of such applications as collaborative videoconferencing. Because ATM is so expensive, we are investigating the feasibility of establishing a vendor partner in a joint development project supporting ATM implementation.”

Costs
The ATM pricing structure is in flux. Costs for some ATM products that contribute to the development of an ATM configuration are decreasing, but the total outlay for an ATM network remains substantial. A desktop ATM configuration from FORE Systems begins at $500 per adapter and $1,000 per switch port. Cisco’s LightStream 1010 ATM platform starts at $19,000, a savings of $11,000 off of the pricetag for Cisco’s LightStream 100 model. There are, however, other economic factors. Investing in ATM also involves expenditures for such essentials as installation, transmission, and ATM-equipped protocol analyzers which can cost as much as $150,000. ATM per port costs from Pacific Bell are $5,000 for installation plus $4,850 monthly for DS-3 (45-Mbps) and $8,500 for installation plus $7,899 monthly for OC-3 (155-Mbps) [http://www.pacbell.com/Products/ATM/atm-1.htm].

Steve Huber [personal communication, June 24, 1995], Manager of Advanced Technologies at Lockheed Martin Corporation, noted that the price of an ATM installation for a large corporation with four branch facilities nationwide is an estimated $245,000. It is likely that demand for ATM in a university environment will accelerate when this technology can be used to bring real cost benefits and reliable performance to everyday network operations and specifications for ATM interoperability, high performance interfaces, transmission, traffic management, switching, and quality of service parameters are more clearly defined.

Conclusion

ATM can support high performance, leading edge educational applications that reshape the learning environment. Migration to ATM requires careful planning. The Internet is a rich source of information for monitoring ATM advancements [Littman 1995b]. Information on ATM can be found at such Web sites as http://www.atmforum.com:80/, http://www.npac.syr.edu:80/users/hariri, and http://cell-relay.indiana.edu/cell-relay/.

My research to date indicates that ATM based networks can enhance and enrich the learning experience. An understanding of ATM technical capabilities is essential in order to address effectively challenges associated with the design and development of ATM applications for instructional use.

References

Abstract: Education for the professions is moving to new curriculum to foster deeper understanding, improved ability to apply knowledge, and reflective practice. Software tools are needed to support new forms of organization, improved collaboration, and increased ability to reflect on experiences. This paper describes the development of a first implementation of Internet based software for keeping reflective journals which support learning from field experience by students in a teacher preparation program. The software supports students (1) capturing and sharing accounts of experiences, (2) linkage to resources, and (3) various modes of conversation and discussion about experiences by groups.

The Context

Traditionally professional preparation programs have been based on models of technical rationality, that professional practice is primarily the manipulation of available techniques to achieve chosen ends in the face of manageable constraints. Donald Schon [Schon, 1983] in his seminal book on professional practice reported on samples of work from various professional fields, including architecture, psychotherapy, engineering and management. Schon described how expert practice depended on artful inquiry into situations of uncertainty. The professional was engaged in a reflective conversation with the uncertain situation, taking stances, experimenting, and learning from the back-talk of the situation. This model of professional work as a reflective practice guides much of the current reform of professional education, including reform of the undergraduate teacher development program in the College of Education (COE), University of Missouri-Columbia.

This changed model of professional work accompanies advances in cognitive psychology which increasingly reveal a picture of learning grounded in active participation, constructed knowledge and the importance of the situation and context not only for what is learned, but for how it will be able to be used. These new theoretical underpinnings, as well as other forces, are pushing education and especially professional education toward learning through problem solving, authentic projects, apprenticeships, and field experiences, and toward learners who act as reflective practitioners. These changes have also caused educators to question traditional models of assessment. We are changing from assessment models of tasks abstracted from practical situations with an emphasis on reliability and efficiency of scoring to a model that depends on capturing authentic, contextually-based performances which can be shared, reviewed and evaluated. Teacher educators are challenged to provide field-based experiences to their students, to support student learning in these experiences, and to assess student outcomes. Meeting the challenge of field-based learning can be supported by advances in technology, in particular the Internet. We now have the potential to design instruction which is far less bounded by time and distance and restricted by the limitations of a classroom. Teachers and learners can connect in many different ways offering new opportunities for learning in context, for richer means of communication and sharing, and for new means of performance assessment.

The Approach

Our COE is capitalizing on an improved understanding of learning and on new technology to transform the way we teach and support learning and performance in our educational community. Two key initiatives of the college are: (1) a partnership with school districts engaged in school improvement and professional
development, and (2) a restructured undergraduate teacher preparation program with an emphasis on field experience. In practice this means that at both the undergraduate and graduate level teaching and learning at the College will increasingly be situated in the practice of real schools. This means that students (practitioners) need to be supported as they take on new challenges, be connected to colleagues and COE faculty who may be distant, systematically be encouraged and supported as they reflect and report their actions and learning outcomes, and be assessed on their achievements in real schools. We envision a network infrastructure and interactive instructional software supporting students, field-based mentors and college faculty as they collaborate, engage in practice, document their efforts, share their experiences, and assess outcomes. We plan a suite of tools that utilize the Internet and work as a system to support collaboration, communication, knowledge access and multimedia production.

The first version of the instructional software, which we are conceptualizing as an environment for keeping an electronic journal, enables the preservice teacher to record their observations and reflections about experiences, maintain these records on a COE server, and organize the records to meet a variety of needs. The software also facilitates sharing these records with faculty, mentor teachers and other preservice teachers as appropriate. In addition the software provides access to a variety of resources for enhancing experiences and solving problems. Among the resource types are on-line archives of knowledge about teaching and learning, links to other appropriate on-line archives, references to off-line support material, and electronic messaging and conferencing with faculty, mentor teachers and other preservice teachers. A key aspect of the development work is to implement support for encouraging and improving students processes of reflection upon their experiences.

The Electronic Journal

The journal system utilizes personal computer clients and Silicon Graphics Indy servers. The first round of software development has created client software for the Macintosh platform. The clients and servers communicate over the Internet using TCP/IP connections. Anyone who has access to the Internet via a direct connection or a SLIP or PPP connection is able to participate. In addition the software supports the creation and editing of journal entries off-line for later upload when a connection is available.

![Interactive Journal](image)

**Welcome screen for Interactive Journal.**

In addition to the features and functions that are supplied by the journal system client connection with the journal system server, the software integrates both web-browsing and e-mail for a full-functioned
environment that supports communication and collaboration with the central mechanism being the shared journal. Figure 1 shows the basic tools available to students once they have signed onto the system. The following categories of functions and features are being implemented in the journal system:

- the creation and editing of multimedia journal entries. In the first version text, images, and web links are supported. In the following version audio and video will be supported.
- the sharing of journal entries with other members of the community
- the ability to add comments and feedback to a journal entry
- the designation of tasks that a member of the community is to complete.
- access to informative and instructional resources: web pages, documents, and software
- access to e-mail within the journal client
- access to a web-browser within the journal client
- a multi-way text chat facility for real-time interaction from the journal client
- access to news and information that is important to the community of user

Figure 2: Form for journal entry

Each member of the community uses the client to build and maintain a journal and a user profile. (The user profile lets the members of the community communicate information about themselves.) The journal entry screen [see Fig. 2] enables the student to create a journal entry which can include imported graphics and links to URLs. The student can also view notes appended by the teacher and other students which are appended to the journal entry. The journal editor is designed to support and promote reflection; reflection is a key attribute of the journal writing activity. Members also use the client to view other members journal entries and to access information that is relevant to the community. Other tools available in the interactive journal interface allow
students to view archived information and resources and use communication tools. The journal interface provides support for integrating dynamic and changing information such as your journal entries for your daily experiences with archived sets of resources which may be available through archived html documents on a web server.

The Design Process

Our general approach to the design and development process is to use a small cohort of collaborators as participant designers from the very beginning of the project. These collaborators represent the prospective end-user community and serve to provide insight and review for a rapid prototyping process. As the project progresses to alpha software we will target a wider section of practitioners for feedback, and then implement a beta version into the real curriculum and practitioner experiences.

This project began in the winter of 1995 with a proposal which was developed and funded to build a set of software tools to support learning from field-based experience. The development team worked during the summer with a teacher education liaison to articulate key needs and key opportunities for implementing technology into the new undergraduate teacher education program. This worked refined the vision and focused our efforts toward a tool which could enhance and build upon faculty use of journalling techniques within their courses. The faculty value having students keep journals as a teaching and learning tool and have developed creative approaches to using these journals, but for the most part the use of journals is too slow, too time intensive, primarily private, primarily episodic (its hard to build and support continuity from journal entry to journal entry), and difficult to maintain. Moving to an electronic environment could enhance continuity across experiences, enable sharing among students, facilitate faculty in providing guidance and feedback, and improve the student’s ability to be reflective, not just descriptive of their experiences.

Scenario

Having formed clear objectives for the support of teaching and learning during field experiences, the next step was to create scenarios of user performance. These scenarios serve as low fidelity prototypes to generate requirements for the systems development. Included here is one example of a scenario based on a plan-do-review format for learning from experiences.

Planning

Dr. Faculty wants Teacher Ed students to visit Ms. Teacher’s class at Local school during the reading period. He has arranged with Ms. Teacher for each Teacher Ed student to administer the reading diagnostic test to individual students in the Local school class. The Teacher Ed students have learned how to use this instrument during a university class, and Dr. Faculty would like students to see how it works in real practice and to analyze the results for a live case.

Dr. Faculty opens his interactive journal and selects a new assignment form. He keys in his directions for the assignment and adds a link to the home page for the Local school so everyone can get access to a map and learn about Ms. Teacher’s class before going out to the school. Dr. Faculty identifies 3 outcomes for this assignment. The first is a journal description of the process of administering this test. He attaches a link to the topic book which contains information and procedures for implementing this test and which includes some sample descriptions from prior Teacher Ed students. The second outcome is for the Teacher Ed student to write a report for the teacher about the test results and implications for further instruction. The third outcome will be a journal entry about the experience of having given the test and written the report for the teacher.

Dr. Faculty sets the dates for start and completion of each outcome and then sends the assignment to the class.

That evening a Teacher Ed student logs into her journal and notices that she has a new assignment. She opens the assignment form and reviews the instructions. She remembers confusion during the class discussion about the validity of the instrument. She keys into her journal a note about this problem and her confusion about how she will interpret the results. She posts this note to her class group. She also notes that the due date for the report to the teacher is the day of the midterm. She keys this concern into her journal and posts it to Dr. Faculty. She checks her calendar and decides to do her diagnostic test on next Tuesday. She clicks the “schedule your time”
link on the assignment form and puts her name on the sign-up sheet. She then uses the link to the topic book to review the diagnostic instrument.

Doing

Its Tuesday morning (how could it possibly come so quickly).... Teacher Ed student opens her journal and notes that there are 3 responses from classmates about her concern for validity. One of the responses notes a place in the topic book which deals with this concern and has put a link to it. She also gets a response from Dr. Faculty about the timing of the midterm. “As a professional Teacher Ed student will have to manage many competing demands. blah, blah, blah.”

After finishing the diagnostic test with the student, Teacher Ed student sits down with her audio tape and powerbook to describe the process of administering the instrument. She brings up the journal entry and starts to key in her description. She uses the capture audio tool to add a short clip of the student reading aloud. Later she will connect to the college network and upload her report as her first outcome for the assignment.

On Tuesday evening, back in her dorm, Teacher Ed student connects to the college network and opens her journal tool. The journal tells her that she has entries waiting to be sent to the server. She clicks OK and her first outcome is transmitted.

Review

Thursday afternoon Teacher Ed student opens her journal to review for the midterm. The journal provides a reminder that her report to the teacher is due and she should be entering her reflection outcome. She dismisses the reminder and continues her preparation for the midterm.

On Sunday evening Teacher Ed student opens her journal to see what is in store for the coming week and gets her reminder for the reflection outcome. She clicks OK and is placed in the assessment assignment form. She opens the reflection object. A “tool” palette for reflection supports becomes available.

The first tool offers a list of possible questions. Each question has been written to support the general reflection process and includes description, analysis and affect types of question. (over time students we expect the reflection object to support moving students to higher order questions)

The second tool provides access to a list and related documents for key issues for reflection about assessment topics. This collection is contained in the topic book for assessment and includes reflection issues from students in previous classes which the faculty have found to be of high interest and value.

The third tool provides access to a list and related reflections from classmates currently undertaking the class.

Teacher Ed student selects the list of questions and selects one, which creates a header for her reflection object and places her in text entry mode. When she completes her reflection, she clicks “send and her outcome is transmitted to the server.

At this point she receives a note from Dr. Faculty (auto sent after submission of outcome 3) instructing her to read two of her classmates outcomes 1 and 3 and then make a contribution to the classmates reflection outcome.

Six days later when the faculty member is reviewing the journal entries he selects two which provide a new insight into the topic. Along with making general contributions to some of the students journal entries, he also sends a note to the two students requesting permission to include their entries in the topic book.

User Testing

Following the development and review of several scenarios we generated a set of functions and processes which could be implemented as an iteration of the journal system. This decision making was based on finding a set of functions which would yield a sufficient set of support for the key teaching and learning objectives and yet be able to be programmed by our development team by Spring, 1996, which was our first opportunity for a course based field test. Following this specification of requirements and getting our software developers on task, we then generated a Hypercard representation of the interface and processes so as to engage
in focus group discussion with our teacher education faculty. These discussions led to a refinement of the software processes, making them a better fit for the teaching and learning process we want to support. The discussions also advanced user education, so that the faculty now are able to think more creatively about what an electronic support environment for reflection might entail. This is leading to changes in their view of assignments and objectives for field experiences.

The first version of the software represents an exciting electronic support tool, but also represents only a part of the vision for supporting field experiences. One key example is that in first implementation students are able to represent their thoughts and experiences with text and graphics, but eventually we will enable them to use audio and video media and perhaps other forms of media, such as simulation. We are confident that we can make the technology advances to enable multimedia representations, but what will this mean for the student process of creating a journal entry, as well as how will this improve or change the meaning conveyed by journal entries to other students. we expect that richer media will enable more articulate journal entries, but this surely will depend upon media literate students. A goal of the project is to identify and investigate these new issues which are a result of the opportunities created by the technology and have potential for significant improvement in learning from experience.

Conclusion

Lessons learned from the scenarios and user testing will contribute to an improved implementation of the first version of the software and to new design goals for the second generation of the software. We anticipate that the software developed in this project will lead to two results. The first is a community of educators and preservice educators at the University of Missouri who will use the software to improve learning through field experiences. To this extent the software and technology infrastructure will need to grow and evolve with the community. We expect that in some ways the software will push the community to new opportunities and in other ways the community will pull the software with new sets of requirements which make it a better fit for their work and learning. The second result is a set of software and architecture for sharing and learning from experiences which can be generalized to other settings. We expect that the core server and client functions for data storage and retrieval, and the mechanisms and protocols we develop for sharing and reflection can also serve engineering students on their senior design project, as well as other field based experiences in professional schools.

References

Abstract:
In this paper, we briefly describe the instructional purposes and design of the dissection, also known as Net-Frog. We discuss the importance of the World-Wide Web for development, distribution, and use of instructional materials. We then describe the quantitative methods used for monthly analysis of the WWW HTTPD server access logs to determine user patterns and access trends. Net-Frog is a heavily visited educational web site. More than 166,821 separate visits were logged in its first seventeen months. Finally, we consider how the data derived can provide useful input for program evaluation and future development efforts.

Valerie Ann Larsen
Sun Mar 24 14:13:44 EST 1996
Introduction

The Internet and World-Wide Web (WWW) provide access to effective instructional materials in a variety of media and an effective distribution channel for educators. Net-Frog, the WWW version of the Interactive Frog Dissection, has afforded an interesting opportunity to explore instructional design and delivery in a new medium. The volume of client-server activity at this site has forced us to build some tools and modify others to explore how this medium is being used.

Valerie Ann Larsen
Sun Mar 24 14:13:44 EST 1996
Purpose and History of Net-Frog

In recent years, the practice of frog dissection has become a controversial topic for moral, economic, environmental and educational reasons. Use of animals in the laboratory is of critical concern to animal-rights activists [Orlans, 1988]. Specimens are collected in the wild and are expensive. From an educational perspective, students are often not well-prepared to learn from dissection [Kinzie, Strauss & Foss, 1993]. The original videodisc-based program, Interactive Frog Dissection was devised to help address some of these issues. Research results on the efficacy of simulation suggest that the program can be effectively used as a substitute for dissection or to better prepare students for the experience of real dissection [Strauss & Kinzie, 1991], [Strauss & Kinzie, 1994], [Kinzie et al., 1993]. The emergence of the WWW on the Internet provided the distribution medium for these interactive multimedia materials. Development for the WWW expands accessibility of instructional materials and eliminates the need to develop for multiple platforms.

Net-Frog, the version developed for the WWW, provides an on-line laboratory dissection experience. It helps students learn the anatomy of a frog and gives them a better understanding of the anatomy of vertebrate animals in general. Specimens are depicted with 60 in-line color images to highlight the visual similarities and differences in the frog anatomy. The student proceeds at his/her own pace through the following sections: Introduction, Preparations, Skin Incisions, Muscle Incisions, and Internal Organs. QuickTime movies demonstrate dissection techniques and provide information unavailable from still photographs. Interactive practice involves users in the experience, asking them to identify critical locations for various dissection procedures and to find various internal organs. Feedback is provided, and the user can always review before attempting a practice activity. The program encourages user feedback through an electronic feedback form for collection of qualitative data. Quantitative analysis of the usage volume and usage patterns at the site are useful tools for assessing the current program and planning future development efforts [Kinzie, Larsen, Burch & Boker, 1996].
Need for Statistical Tools

Although the target audience for Net-Frog is students in high school biology classes, it is publicly accessible by anyone with access to web browsers and other pertinent helper applications. The site received favorable attention from the national press in September, 1994, with the result of substantially broadening its potential audience. We maintain that understanding the behavioral patterns of those who use these instructional materials can contribute to enhancement of this product and better design of future WWW materials.

One issue which surfaced during an analysis of users and usage on the Cleveland Free-Net was that a computer usage report does not report how the data is utilized or manipulated [Anderson, 1992]. This study suggested that usage behavior should be evaluated by assessing usage patterns as well as usage volume. WWW servers record every request for information into cumulative files (access logs). Methods of sorting and rendering this raw data into formats appropriate for analysis, including visualization of access activity [Pitkow & Bharat, 1994], are being explored at various sites. The YAHOO web directory on the World-Wide Web now carries a distinct section on Log Analyzers (tools for analyzing access logs) with links to a wide array of information and software pertinent to log analysis [YAHOO!, 1996].

Currently, mechanisms for analysis of the raw data in the WWW access logs are limited. For a frequently accessed Web site, the volume of access information can quickly become overwhelming. Therefore, statistical analysis of information about a specific site is difficult to acquire and yet essential. We hope eventually to expand the available tools for statistical analysis of Web usage within specific sites (Net-Frog in this instance).

Valerie Ann Larsen
Sun Mar 24 14:13:44 EST 1996
Methodology

WWW browser software establishes a client-server relationship in which part of the program (the client) resides in one location such as an individual's computer while the other part (the server) resides on a system such as the Web server at the University of Virginia's Curry School of Education. The raw data used for this analysis was obtained from the HTTPD server access logs made available by members of the UNIX Systems Group, Information Technology and Communication center at the University of Virginia. Whenever a user accesses any portion the Net-Frog, the transaction is logged into WWW HTTP server access logs. If the user retrieves a file from the suggested section or any other section, that transaction will also be logged. All data recording is automatic with raw data stored in electronic media (an IBM RS6000 allocated to the Curry School of Education at the University of Virginia). Raw access data for Net-Frog were extracted from this data base. Using standard UNIX commands, a series of reports were generated which report monthly activity at every level of the Net-Frog menu structure.

We developed software to collect descriptive statistics at a summary level for the entire period [Kinzie, Larsen, Burch & Boker, 1996]. The collected data cover a seventeen month period from the announcement of Net-Frog on August 4, 1994 until December 31, 1995. Subjects for quantitative analysis include all client machines which access Net-Frog or any segment thereof. Results of this study indicated that data should be analyzed at the monthly level as well as a summary level. Tools were modified for monthly measurement of the following: number of clients are accessing the Net-Frog; total client visits; number of unique network domains accessed; identification of trends if any.

We first wrote and executed a C-language program to convert the raw access data into output files readable by SAS (Version 6.09) and S-Plus statistical software (Copyright © 1988, 1992 Statistical Sciences, Inc.). Our WWW server software (NCSA HTTPD 1.1) attempts to resolve IP addresses into more human-readable domain names by polling a name-server at the time of access. IP addresses not having a corresponding domain name remain unresolved at this point. Only about 75% of our data were resolved to domain name, leaving about 25% unresolved. We compared the unresolved IP addresses with entries obtained from a standard network reference (hiets.unl.now" obtained from ftp.merit.edu on April 6, 1995). If a match was found for the network identifier, we extracted its corresponding domain-style identifier and inserted this into the access logs in much the same way that the original server resolution had been accomplished. By these means, we were able to resolve about 95% of all addresses.

Next, a SAS routine read in the converted WWW log file. This routine performed several functions. References to the Curry School of Education were eliminated to ensure that our program servicing efforts would not influence analysis. We also qualified data to remove unsuccessful attempts to access Net-Frog. Various summary statistics were produced.
including some which provide a cross-check to ensure that our conversion process is producing usable data for sequential analysis at a later time (document count, path count, and time information). The routine generated a file of machine frequencies with records of the day of the month, the count and percent of total usage by that machine. Request activity within a 24-hour period was processed as a single machine visit. If a client machine accessed Net-Frog over a number of days, the machine was considered to have made multiple machine visits [Kinzie, Larsen, Burch & Boker, 1996].

Finally, a program in the S-Plus statistical language read the qualified data files from SAS output and calculated summary values for the data transported to users. This routine was also modified to permit analysis by month. We were curious about patterns which may have developed in the different Internet domains. We therefore generated an S-Plus software program to plot the number of visits per month by Internet domain.
Results

A total of 3,776,477 files and over 143.4 billion bytes were served within the 17 month interval between August, 1994 and December, 1995. A monthly average of 222,146 files and over 8.4 billion bytes were served, resulting in an average of 22.64 files and 863,645 bytes served per machine visit. We recorded 166,821 total machine visits, with a monthly average of 9,813 visits. We found that a number of the clients making these visits were repeat visitors. We recorded 6,888 unique machine addresses served per month and 117,091 unique machines have been identified since Net-Frog was announced. Figure 1 displays these and other summary activities.

Net-Frog activity reflects one of the interesting findings about global accessibility. Within its first month, August, 1994, the site was visited from 43 different domains. By October, two months later, 57 unique domain networks had accessed Net-Frog. Since then, an average of 60 domains visit each month. Our data resolution efforts have resulted in the identification of 90 unique Internet domains over seventeen months.

Figure 2 presents the total number of machine visits per month and the number of unique machine visits per month. Publicity and/or media attention may have influenced site activity. Table 2 provides an example of some favorable attention received by Net-Frog from the press and various WWW sites. We hypothesize that the peak in October, 1994 reflects the intense file activity after favorable attention in a Newsweek article in September, 1994. Following a reference in Internet World in January, 1995, which referred to Net-Frog as one of the three best sites appearing in 1994, we saw another upswing in visitation which peaked in April, 1995. Another peak occurred during the fall of 1995 after the site was ranked among the top 5% of all Internet sites. We will watch for indications of another surge of activity to the site following announcement of the IWAY 500 award of February, 1996.
Clients who accessed Net-Frog were located primarily in the United States; 81% of the requests that could be traced to a domain were US-related, with 36.6% from U. S.
Educational institutions, 26.6% from U.S. Commercial addresses, 10.1% from Network addresses. International requests from Canada (4.5%), the United Kingdom, (3.5%), Germany (1.8%), Australia (1.3%), Sweden (1.2%), and the Netherlands (1.1%) were notable. Table 2 provides a summary of the percentage of total activity between August, 1994 and June 1996 for all U.S. domains and for the three largest domains within the U.S.

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<tr>
<td>Jan '96</td>
<td>Mosaic Access to the Internet</td>
<td>Tauber, D. A. &amp; Kienan, B. -- &quot;One of the most famous and, in our opinions, best, examples of use of the Web ...&quot; and,</td>
</tr>
<tr>
<td>Feb '96</td>
<td>Iway Magazine</td>
<td>Ranked among the top 25 science-related sites in their review of the best 500 web sites around the world</td>
</tr>
</tbody>
</table>

Table 1. -Net-Frog Publicity

<table>
<thead>
<tr>
<th>Domain</th>
<th>% of Total by 94-08</th>
<th>% of Total by 95-06</th>
<th>Cumulative % by 95-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total U.S.</td>
<td>79.22</td>
<td>78.2</td>
<td>80.97</td>
</tr>
<tr>
<td>U.S. Commercial</td>
<td>26.75</td>
<td>28.31</td>
<td>36.55</td>
</tr>
<tr>
<td>U.S. Educational</td>
<td>37.69</td>
<td>31.7</td>
<td>26.55</td>
</tr>
<tr>
<td>Networks</td>
<td>3.58</td>
<td>8.9</td>
<td>10.08</td>
</tr>
</tbody>
</table>
Table 2. - Percentage of Accesses by Top Level Domains

To better understand the nature of this fluctuating activity, we decided to plot graphs of machine visits for every domain over the past 17 months. As noted above, the two primary domains in Net-Frog usage are U.S. Commercial and U.S. Educational. Figure 3 depicts two widely divergent usage patterns. Commercial usage follows a relatively linear growth pattern for the first fourteen months and remains near that maximum for the final three months. The U.S. Educational domain depicts seasonal fluctuations that coincide with the school year. The peaks in the educational domain usage also coincide with the national publicity received by the site.

Figure 3. - Net-Frog: Monthly Domain Activity

Next: Discussion  Up: Net-Frog: Analyzing Monthly  Previous: Methodology

Valerie Ann Larsen
Mon Mar 25 08:15:17 EST 1996
Discussion

Identification of learners and their behavior is a primary issue within the discipline of instructional design and delivery. Some of this information is available through qualitative input via a voluntary self-report feature in the Net-Frog. Although Web access logs contain little demographic information, it remains a rich data source for general client-server patterns.

There are some obvious problems associated with analysis of usage behavior derived from access logs. Web access logs display the number of times that a client accesses a file but may not reflect the frequency with which a user looks at a file which is pulled from a server and stored in cache. As statistical tools, SAS and SPSS are not well-suited to sequential analysis. Because of this, we have defaulted at this time to the above-described estimation method for determining unique machine visits. Our next research phase is development of an event-history analysis of client usage patterns (using S-Plus) to pursue topics such as the amount of time the program is used (would be a minimal estimate, based on time of first and last document requests), identification of who is using Net-Frog multiple times on different occasions (number of time, number of sites, number of times each) and the total time clients spend at an individual web site.

Valerie Ann Larsen
Sun Mar 24 14:13:44 EST 1996
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YAHOO!, 1996
About this document ...

Net-Frog: Analyzing Monthly User Access Patterns on the WWW

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Valerie Ann Larsen
Sun Mar 24 14:13:44 EST 1996
Obstacles to the Implementation of Computer-Assisted Reporting Courses

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Abstract: Computer-assisted reporting, or CAR, includes the use of computers by reporters for gathering and processing information in every phase of news story development. A panel of educators and journalists with experience in CAR addressed the following questions in this study: What benefits will journalism schools realize from the introduction of computer-assisted reporting courses? What problems will the schools encounter in the process? How might those problems best be addressed?

The Delphi method was used to seek consensus among a panel of CAR experts regarding the benefits, problems, and problem solutions associated with introduction of computer-assisted reporting courses in journalism schools. The Delphi respondents foresee a plethora of benefits for students in CAR programs. According to the panel, students will acquire knowledge vital to their future jobs and beneficial in other university courses; develop statistical, analytical, and computer-reporting proficiencies; enjoy an improved learning environment; and have a broader perspective of available news sources. The most likely problems university journalism programs will encounter in the process of introducing CAR courses are cost of equipment, lack of qualified faculty, maintenance of equipment, class sizes limited because of equipment costs, and curriculum revision necessary for CAR courses.

Introduction

An investigative reporter for a major midwest newspaper recently utilized a computer to compare one state's department of corrections database of over one-half million convicted criminals with their education department database of 100,000 teachers and bus drivers. He discovered there were nearly 200 convicted felons in the state's classrooms and another 200 driving buses. The charges included murder and child molestation. The education department admitted negligence in checking applicants' records, and the state quickly passed a statute requiring criminal checks on all teachers and drivers [Borsi 1993].

There is little question that journalists with CAR skills, such as the reporter above, are in demand. Noting that reporters using computers for data retrieval and analysis have won Pulitzer Prizes the last six years in a row, U.S. News and World Report recently listed CAR specialist for print media as one of 20 "hot job tracks" for the future: "Journalists can improve the odds of breaking in and moving up by mastering computer-assisted reporting techniques.... Dozens of papers have trained or hired specialists in computer-assisted reporting in the last few years, and more will as the costs of equipment drop and databases become available through online services [U.S. News 1994]."

Computer-assisted reporting, or CAR, includes the use of computers by reporters for gathering and processing information in every phase of news story development: obtaining story ideas from computer databases, online services, networks and bulletin boards; collecting and analyzing information from government and private databases; verifying information received from human sources via online services and databases; and creating databases at the newspaper to statistically analyze information for stories and graphics [Paul 1994].

Despite advances in computer-assisted reporting being made by America's newsgatherers, most university journalism programs have yet to introduce their first CAR course. However, fundamental CAR techniques are quickly becoming part of the standard repertoire in many of the nation's newspapers. Beginning with a literature review, this paper outlines a research study addressing this disparity.

Referring to the rapid development of computer-assisted reporting in newsrooms, Jim Brown, director of the National
Institute for Advanced Reporting, said, "Those in the job market now who don't know how to use a spreadsheet or a database are really at a competitive disadvantage ..." [Feola 1995]. Two-thirds of the 208 newspapers responding to a spring 1994 survey of dailies "use computers in some manner for some type of reporting" [Garrison 1995].

The use of computers by journalists is not new. Ward, Hansen, and McLeod identify the introduction of video display terminals (VDTs) and electronic pagination software as major technological changes in the newspaper industry beginning over two decades ago. The adoption of VDT technology changed writing, editing and production processes, while the electronic pagination systems transferred much of the back-shop production work to the journalists' desks [Ward, Hansen and McLeod 1988].

In addition to editing and pagination functions, newspapers are now regularly utilizing their computers to access online databases, search computerized public records, and scrutinize government documents. In 1983, John Ullmann reported that 20 of the 54 newspapers with circulations of 100,000-plus which he surveyed subscribed to one or more database service [Ullmann 1983].

Tim Miller, writer and consultant, studied the use of databases by journalists during his year as a research fellow at the Gannett Center for Media Studies. He found that the number of newspapers conducting online database searches quadrupled from 1982 to 1986 [Miller 1988]. In a study of 96 randomly selected general circulation daily newspapers with circulations of more than 25,000, Frederic F. Endres found that 21 of the publications utilized commercial computer service networks, such as Nexis and Dow Jones, to access databases and BBSs by 1985 [Endres 1985].

Endres, professor of journalism at Kent State University, discovered that most of the papers had been using database services for a year or less. Regarding the future of database use, 18 of 21 said they would either continue with the current subscription or add more. Respondents said the database services were used to gather story information in several areas: facts on individuals and corporations, details of political events, sports statistics, weather data, business information, and background material on persons, companies, or events [Endres 1985].

In 1987, Hansen, Ward, and McLeod found that 38 percent of the newsroom staff members they surveyed at one metropolitan daily with a circulation of 385,000 used electronic database sources. The sample population consisted of the newspaper's 195 reporters, editors, columnists and editorial writers. One hundred thirty six, 69.5 percent, responded [Hansen, Ward and McLeod 1987].

In 1989, Jacobsen and Ullmann found that 71 percent of surveyed journalists said database searches were an "important" or "very important" component of their news reporting. Questionnaires were distributed to librarians at the 235 U.S. newspapers with circulations of 50,000 or more. The librarians were asked to pass along questionnaires to reporters or editors who used databases. Eighty responded. Seventy six percent said their searches were "almost always" useful. The perceived benefits listed by the respondents included improved detail, depth, and perspective for stories, as well as access to a wider geographic range of coverage and improved "memory" of facts. The study indicated that potential problems related to database use were not a matter of great concern. The journalists responding generally were not worried about databases leading to homogenization of coverage, adversely effecting reporting angles, or contributing to a loss of local perspectives in reporting. Nor were they very concerned that database use would discourage original work or bury reporters in data [Jacobsen and Ullmann 1989].

In 1991, Ward and Hansen found that 90 percent of the 105 newspapers with circulations of 100,000-plus they surveyed subscribed to at least one database service, with a median number of four taken. In 60 percent of the newsrooms equipped with PCs and modems, reporters searched public records electronically.

The results of this study show that electronic technologies have been adopted in a large majority of the nation's biggest dailies. These technologies are used for information search, selection and analysis... the use of the personal computer for "computer-assisted reporting" allows creation and analysis of information never previously available for news reports [Ward and Hansen 1991].

In a July 1992 survey of daily newspaper managing editors, Brian S. Brooks and Tai-en Yang, University of Missouri, found that 90 percent of the large newspapers (100,000-plus) and 55 percent of the medium-size papers (50,000 to 100,000) had conducted investigative reporting using a computer. One hundred percent of the large and 52 percent of the medium papers had used newsroom computers to "access external databases." Forty-one percent of large newspapers had used computers to read nine-track tapes. The Nexis/Lexus database had been accessed "regularly" by 78 percent of the large papers, followed by DataTimes, 68, Vu/Text, 59, Dow Jones News, 41, and CompuServe, 39 [Brooks and Yang 1993].
Three-fifths of the newspapers responding to Garrison's 1994 survey of dailies used online services of some kind. Fifty-two percent used spreadsheet software for CAR, 48 percent relational database software, and 36 percent CD-ROM readers. Forty-seven percent had created, or planned to create, a "CAR desk" or CAR project team [Garrison 1995].

These studies point to the fact that computer-assisted reporting is quickly becoming the norm for U.S. newspapers. Journalism schools have been slower to embrace these advances in newsgathering technology.

Research Questions

If universities continue the pattern they established following the introduction of VDTs and pagination systems, then CAR courses eventually will be introduced in journalism schools. Discussions concerning the future of CAR courses, therefore, should focus on "When?" and "How?" rather than "If?" This study has taken that approach.

A panel of educators and journalists with experience in CAR addressed the following questions in this study: What benefits will journalism schools realize from the introduction of computer-assisted reporting courses? What problems will the schools encounter in the process? How might those problems best be addressed?

Methodology

The Delphi method was used to seek consensus among a panel of CAR experts regarding the benefits, problems, and problem solutions associated with introduction of computer-assisted reporting courses in journalism schools. The Delphi is a research methodology designed to solicit expert opinions regarding the predicted future of a particular domain. This research technique was developed and refined during the 1950s and 1960s by the Rand Corporation to help the United States military develop long-range strategies. Since that time Delphi has been used widely in business, science and government [Allen 1978].

This Delphi study utilized a non-random sample of expert subjects. The panelists were selected based on their depth and span of experience with CAR as professional journalists or as university journalism instructors. Nominations were collected from personal interviews, articles in scholarly and trade publications, professional and academic credentials, and participation in CAR seminars and conferences. Some respondents have primarily professional experience with CAR, some primarily academic, and some a blend of the two.

Panelists included professional journalists working for numerous newspapers, a wire service, a newspaper conglomerate, a national news magazine, and a broadcast network news program. Some are Pulitzer-Prize winners or finalists. Several of the respondents hold newly created CAR positions with titles such as "database reporter," "systems analyst," "computer specialist," and "new media manager."

The panel of experts also included faculty members in higher education journalism programs at institutions ranging in size from large state universities to small colleges. Other participants included the directors of two independent CAR institutes, and library directors for a large journalism school and a national media institute.

Three rounds of questionnaires distributed in the fall of 1994 served as the research instruments for the Delphi. The first and third rounds consisted of open-ended questions designed to foster a free flow of opinions from the panelists. The second round asked respondents to rate and rank a series of statements based on Round I responses. Round I asked panelists to list up to five benefits and up to five problems associated with the introduction of computer-assisted reporting courses in university journalism programs. In Round II, experts rated the likelihood of problem statements generated in the first round on a five-point semantic differential scale ranging from "unlikely" to "likely." They also ranked the top five problem statements according to magnitude. Round III asked panelists to suggest possible solutions to the top five rated and ranked problem statements from Round II.

The Results

From a master list of 53 potential respondents, 33 journalists and journalism educators completed a reply form agreeing to participate in the Delphi study of computer-assisted reporting. Each of the 33 was sent a Round I questionnaire. Thirty returned completed questionnaires, yielding a return rate of 91 percent.

In Round I respondents listed 123 potential benefits. Similar answers were consolidated into 35 benefit statements, which fell into four broad categories: student-related, graduate-related, faculty-related, and journalism program-related.
The Delphi respondents foresee a plethora of benefits for students in CAR programs. According to the panel, students will acquire knowledge vital to their future jobs and beneficial in other university courses; develop statistical, analytical, and computer-reporting proficiencies; enjoy an improved learning environment; and have a broader perspective of available news sources.

Additional predicted student-related benefits include an increased emphasis on journalistic inquiry and on facts rather than personalities; increased access to diverse viewpoints; development of connections with news professionals; heightened awareness of First Amendment and privacy issues; and realization of the importance of access to public records. According to the panel, graduates of CAR-enhanced journalism programs will also reap a harvest of benefits, including an easier time securing journalism jobs; an easier transition to other computer-related jobs; an understanding of computer capabilities beyond word processing; and a clearer perspective of the contemporary world of computer communication.

The respondents also listed graduate-related benefits that will profit others. These include an ability to use CAR for investigative reporting to inform the public; an ability to use CAR methods to generate story ideas for print and broadcast news organizations; and an opportunity to introduce CAR to news operations that have not used it. Panelists also foresee university journalism professors as re-energized beneficiaries of CAR-enhanced programs. Faculty-related benefits include the motivation to stay current with developments in the profession; the development of more common ground between profession-oriented and research-oriented faculty members; the ability to utilize CAR databases for academic research; and the development of new connections with colleagues in other departments/programs.

Looking at the bigger picture, the respondents noted several benefits journalism programs will enjoy. These include an overall increased attractiveness to better professors and students; increased attractiveness to computer-oriented students, older non-traditional students, and mid-career professionals seeking CAR training; development of new connections with news professionals; and procurement of funding from organizations supporting CAR. Journalism school benefits also will include the opportunity for programs to become more contemporary; an increased chance of "survival" in the university; the opportunity to use CAR as a marketing/PR tool; and a better reputation among faculty in other disciplines.

Also in Round I, the panelists listed 108 potential problems. Similar answers were consolidated, and a master list of 26 problem statements was developed for use in Round II. These were grouped into five broad categories. Some problems were included in more than one group:

1) Equipment-related problems included "cost of equipment," "maintenance of equipment," "class sizes limited because of equipment costs," "offering online services to large numbers simultaneously," "lack of standard computer hardware," "lack of standard computer software," "computer hardware becoming obsolete quickly," "computer software becoming obsolete quickly," "CAR techniques becoming obsolete quickly," and "the quality of retrieved data not being assessed."

2) Institution-related problems included "resistance of university administrators," "curriculum revision necessary for CAR courses," "resistance of faculty," "lack of qualified faculty," "faculty who misunderstand economic importance of CAR," and "for purposes of promotion and tenure, faculty will devote time to research rather than learning new CAR skills for teaching."

3) Curriculum-related problems included "CAR taught as a replacement for, not complement to, traditional reporting," "CAR skills segregated in separate courses rather than taught across the journalism curriculum," "curriculum revision necessary," "scarcity of CAR teaching materials," "developing substantive student assignments," "developing new courses in statistical analysis," "the limited number of student internships," and "the quality of retrieved data not being assessed."

4) Student-related problems included "students who are apathetic about CAR," "students intimidated by computers," "meeting expectations of incoming students who have been exposed to new technology in high school and home," and "the limited number of student internships." The first three deal with student attitudes, the fourth with opportunities for students.

5) Cost-related problems included "cost of equipment," "class sizes limited because of equipment costs," and "cost of online time."

For Round II the 29 panelists were asked to rate each of the 26 problem statements, generated from Round I, by means of a semantic differential scale. The respondents checked one of five blanks between the bipolar adjectives "unlikely"
and "likely" for each statement. All 29 participants rated the problems statements. The blank closest to "likely" was scored a five, the next closest four, the center blank three, the next closest two, and the blank closest to "unlikely" one.

Table I lists the problem statements in descending order from "likely" (5.0) to "unlikely" (1.0) based on their overall rating by respondents in Round II. When the means of two problem statement ratings are the same, the statement with the lower standard deviation is listed first.

In Round II, the panelists were also asked to rank "the top five biggest problems you believe university journalism programs will encounter during the process of introducing computer-assisted reporting courses." The respondents were asked to write "1" in the left hand margin of the list next to the biggest problem, "2" next to the second biggest problem, "3" next to the third, etc. All 29 respondents ranked the problem statements.

Table II lists the problem statements in descending order based on their overall ranking by respondents in Round II. First-place rankings were scored with five points, second-place with four, third with three, etc. When the point totals of two or more problem statements are the same, the statement with the greatest number of high rankings (# of 1st places or next highest) is listed first.

According to the Table II scale ratings, the most likely problems university journalism programs will encounter in the process of introducing CAR courses are cost of equipment, lack of qualified faculty, maintenance of equipment, class sizes limited because of equipment costs, and curriculum revision necessary for CAR courses.

According to the rankings, the problems of greatest magnitude university journalism programs will encounter are cost of equipment, lack of qualified faculty, maintenance of equipment, resistance of faculty, and resistance of university administrators.

Table III lists the top five most "likely" problems from the Round II bipolar scale ratings with the top five "biggest" problems from the Round II rankings. Interestingly, "cost of equipment," "lack of qualified faculty," "maintenance of equipment," in that order, topped both lists.

Table IV lists the five problem categories in alphabetical order followed by their mean likelihood and magnitude scores. Overall, cost-related and institution-related were rated first and second both as most likely to occur and as having the greatest problem magnitude.

The use of computer-assisted reporting techniques is clearly an example of adoption of innovations, as DeFleur and Davenport pointed out. They concluded that university journalism programs in 1993 were noticeably "lagging" behind newspapers in their adoption of CAR [DeFleur and Davenport 1993]. The panel of experts in this study agreed. Further, they believe the gap between industry practice and university instruction should be closed. The panelists said problems associated with the introduction of CAR courses can be clearly identified and forthrightly addressed.

Table 1

Likelihood Ratings of Predicted Problems for University Journalism Programs Introducing Computer-Assisted Reporting Courses

<table>
<thead>
<tr>
<th>Problem</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of equipment</td>
<td>4.138</td>
<td>1.145</td>
</tr>
<tr>
<td>Lack of qualified faculty</td>
<td>4.0</td>
<td>1.225</td>
</tr>
<tr>
<td>Maintenance of equipment</td>
<td>3.862</td>
<td>1.167</td>
</tr>
<tr>
<td>Class sizes limited because of equipment costs</td>
<td>3.586</td>
<td>1.350</td>
</tr>
</tbody>
</table>
Curriculum revision 3.586 1.427
CAR skills segregated in separate courses rather than taught across the journalism curriculum 3.483 1.353
Computer hardware becoming obsolete quickly 3.310 1.491
Resistance of university administrators 3.241 1.431
For purposes of promotion and tenure, faculty will devote time to research rather than learning new CAR skills for teaching 3.207 1.256
Students apathetic about CAR 3.138 1.457
Scarcity of CAR teaching materials 3.069 1.361
Faculty who misunderstand economic importance of CAR 3.034 1.017
Offering online services simultaneously to many students 3.034 1.426
The quality of retrieved data not being assessed 2.966 1.163
Resistance of faculty 2.966 1.322
Computer software becoming obsolete quickly 2.931 1.438
Developing new courses in statistical analysis for journalism students 2.896 1.291
Cost of online time 2.862 1.356
Lack of standard computer hardware 2.862 1.633
Lack of standard computer software 2.793 1.449
Limited number of student internships available in CAR-equipped newsrooms 2.759 1.544
CAR taught as replacement for, not complement to, traditional reporting 2.621 1.347
Students intimidated by computers 2.621 1.449
Meeting expectations of incoming students exposed to new technology in high school and home 2.586 1.211
CAR techniques becoming obsolete quickly 2.103 1.263
Developing substantive student assignments 2.069 1.113

Table 2
Magnitude Rankings of Problems University Journalism Programs will Encounter During the Process of Introducing Computer-Assisted Reporting Courses

N = 29

Problem Points #1 Rankings

Cost of equipment 97 11
Lack of qualified faculty 67 9
Maintenance of equipment 30
Resistance of faculty 27 3
Resistance of university administrators 27 1
Class sizes limited because of equipment costs 26
Students apathetic about CAR 18 1
Cost of online time 15
CAR skills segregated in separate courses rather than taught across the journalism curriculum 15
Students intimidated by computers 14
Curriculum revision necessary for CAR courses 14
CAR taught as a replacement for, not complement to, traditional reporting 11 1
Scarcity of CAR teaching materials 10
For purposes of promotion and tenure, faculty will devote time to research rather than learning new CAR skills for teaching 8
Computer hardware becoming obsolete quickly 8
CAR techniques becoming obsolete quickly 7 1
The quality of retrieved data not being assessed 6 1
Lack of standard computer hardware 5
Lack of standard computer software 5 1
Developing substantive student assignments 5
Limited number of student internships available in
CAR-equipped newsrooms 5
Offering online computer services simultaneously
to many students 3
Computer software becoming obsolete quickly 3
Faculty who misunderstand economic importance of CAR 2
Meeting expectations of incoming students exposed
to new technology in high school and home 2
Developing new courses in statistical analysis for
journalism students 1

Table 3
Top Five Problems by Likelihood Scale Rating and Top Five Problems by Magnitude Ranking
N = 29
________________________________________________________________________
<table>
<thead>
<tr>
<th>Problem Scale Pts.</th>
<th>Ranking Pts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of equipment</td>
<td>120 (#1) 97</td>
</tr>
<tr>
<td>Lack of qualified faculty</td>
<td>116 (#2) 67</td>
</tr>
<tr>
<td>Maintenance of equipment,</td>
<td>112 (#3) 30</td>
</tr>
<tr>
<td>Class sizes limited because of equipment costs</td>
<td>104 (#4)tie 26</td>
</tr>
<tr>
<td>Curriculum revision necessary for CAR</td>
<td>104 (#4)tie 14</td>
</tr>
<tr>
<td>Resistance of faculty</td>
<td>86 (#14) 27</td>
</tr>
<tr>
<td>Resistance of university administrators</td>
<td>94 (#8) 27</td>
</tr>
</tbody>
</table>

Table 4
Problem Likelihood and Magnitude Scores for the Five Categories of Problem Statements
N = 29
________________________________________________________________________
<table>
<thead>
<tr>
<th>Problem Category Likelihood</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Rating Pts.</td>
<td>Mean Ranking Pts.</td>
</tr>
<tr>
<td>------------------------------</td>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Cost-Related 3.517 46.0
Curriculum-Related 2.953 8.4
Equipment-Related 3.165 19.0
Institution-Related 3.283 26.2
Student-Related 2.784 9.8

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Garrison, Bruce (1995) "Computer-Assisted News Reporting Tools: A Study of Daily Newspaper Use," research paper presented at AEJMC Southeast Colloquium, Newspaper Division, Gainesville, Florida, March, 11. [Of the papers, 56.3 percent were under 75,000 circulation, 34.1 percent 75,000 to 300,000].


Paul, Nora (1994) Computer-Assisted Research: A Guide to Tapping Online Information, 2nd ed. St. Petersburg, Florida: The Poynter Institute, 2. [Garrison defines CAR as the 'use of computers to gather information for a news presentation.' He identifies two primary realms of CAR: online research, and database journalism -- analysis of created or accessed databases. Similarly, DeFleur and Davenport identify three major areas of computer use by journalists: searching public and commercial online databases, analyzing digitized government records, and creation of specialized databases].


Comparative Analysis of Teacher’s Discourse and Students’ Behaviour in Traditional and Distance Lectures

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Abstract: This paper describes a comparative analysis of a traditional lecture and a distance lecture. We relied on a morpho-syntactic model of text analysis to study the two teacher's discourses and we videoed and categorized students' behaviour. It turned out that, during the distance lecture, students' cognitive load is higher and teacher's discourse is denser and more structured. This can be explained by a loss of information in the interaction which makes the communication more formal. At the end of the paper, we propose the sketch of a new model to discriminate traditional pedagogical discourses from mediatised ones.

Introduction

The Context

Recent innovations in technology have expanded distance education opportunities. Besides the technical aspects, it is important to study the consequences of these new ways of teaching on both the teacher's activity and the students' learning activity.

In the university of Grenoble, France, a college-level course in economics is given by the same teacher in two different ways:
— the first one is a 3-hours traditional lecture;
— the second one is a 2-hours live distance lecture to students located in Valence, a town situated 60 miles from Grenoble.

A software called TéléPresentation™ transmits the teacher voice as well as predefined slides on a numerical line. The teacher is in Grenoble, he wears headphones and a microphone and he controls the slides switching from his computer. He does not see the students. In Valence, students watch a TV screen showing the slides and listen to the teacher's voice. There is a microphone in their room for them to ask questions whenever they want.

This device is much cheaper than usual videoconference and it is interesting to compare a distance lecture using that system to a traditional lecture. After a few weeks observing these lectures, we had the strong intuition that
the distance lecture was much denser and more authoritative than the traditional one. Moreover, students in Valence seemed more attentive and their cognitive load appeared higher. These hypotheses needed to be confirmed by comparing both situations through an observation.

Other Works

Several works have tried to compare traditional and distance communications. It has been shown [O'Connnail et al. 1993] that even in a video conferencing system with optimal video quality and negligible delays, the conversation parameters differ from a face-to-face dialog. Contrary to the authors' expectations, formal techniques are used to achieve speaker switching: there are fewer interruptions and overlaps and longer conversational turns. This distortion of the conversation may affect teacher-students interactions. These interactions have already been studied in a distance course [Zhang & Fulford 1994]. The goal was to study a possible correlation with student's satisfaction. They discovered that student's satisfaction increases with their interaction perception, and that both decrease with a rise of class duration. However, the concept of interaction needs to be better defined because there is no correlation between interaction time and the student's perception.

Our goal is to perform a comparative study of traditional and distance lecture from 2 points of view: the teacher's discourse and the students' behaviour.

Justification of the Method Used for Analysing the Teacher's Discourse

There are several methods for analysing texts. Some of them are purely descriptive whereas others are more predictive. In particular, some try to relate the conditions under which a text is produced to its content. Our goal was not just to express differences between two teachers' discourses but also to relate them to the underlying cognitive processes. We wanted to know more about the teacher's cognitive activity.

One of these methods has the advantage of relying on a cognitive model of discourse production [Bronckart et al. 1985]. Another argument in favour of this method is that, for some reasons, we could not collect discourses on the exact same content (working on the same content would have anyway introduced an experimental bias since the preparation of slides by the teacher for the distance lecture would have affected the structure of his traditional lecture). We could not then perform a semantic analysis and we had to fall back on a morpho-syntactic analysis of the texts.

Bronckart's Method

The main goal of Bronckart and his colleagues is to link the occurrence of morpho-syntactic units in texts with the conditions under which they were produced. They defined 3 situations: situated discourses (theatre dialogs, oral dialogs), narrations (novels, tales) and theoretical discourses (scientific texts). The hypothesis is that these different conditions will affect the cognitive processes of the speaker, therefore leading him to choose such modal auxiliary, such verb tense, such connective to express his ideas. For each situation, Bronckart's model predicts the occurrence of 27 such linguistic units. The model also provides an explanation for these values.

For instance, a theoretical situation will lead the speaker to structure his discourse, therefore using more argumentative connectives such as nevertheless, since, therefore, etc. On the other hand, a situated discourse will contain a great proportion of pronouns of the first and second person because of the live presence of participants in the dialog. In order to test the relevance of this model, Bronckart et al. calculated for 150 texts, 50 of each category, the number of occurrences for 27 units. A discriminant analysis showed that these 27 units were sufficient to discriminate all the texts. In other words, given a text, the method can predict its type (situated discourse, narration, theoretical discourse). Therefore, it can suggest the cognitive operations which governed the text production.

Using this model, we will be able to characterize the distance lecture with respect to the archetypal texts. For instance, is it more of a theoretical discourse, or a situated discourse? Afterwards, the values for each of the 27 units will give us indications on the discourse itself as well as on the underlying cognitive processes.
Methodology

We videoed a traditional lecture as well as a distance lecture. For each lecture, we recorded the students with one camera and the teacher with another camera. Out of the 3 hours of traditional lecture and 2 hours of distance lecture, we picked 10 minutes of each teacher's discourse. We got 2 texts of approximately 1000 words each in which we counted the occurrence of each of the 27 units.

Concerning the study of the students' behaviour, we chose 8 subjects for each lecture. In each group, 4 of them were observed from minutes 30 to 40, and the 4 others from minutes 80 to 90. We noted 4 kind of tasks:
— taking notes;
— listening;
— watching the professor or the screen;
— dropping out temporarily.

We calculated the total duration of each task for each student. Durations were compared by means of the Mann-Whitney test.

Results

Teacher’s Discourse

Applying the counting of the linguistic units for each text [see Tab. 1] to the results of Bronckart's discriminant analysis allowed us to calculate coordinates for each discourse and to place them in a plane beside the 150 texts Bronckart analysed. It appeared that our 2 discourses were within the scatterplot of the theoretical texts. Therefore, the model cannot explain globally the differences that exist between the two lectures. However, specific values for each linguistic unit gave us indications on the nature of the discourses.

<table>
<thead>
<tr>
<th>Linguistic units</th>
<th>Traditional lecture</th>
<th>Distance lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 — Pronoun/adj. 1st person singular</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>2 — Pronoun/adj. 1st person plural</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3 — Pronoun/adj. 2nd person singular</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4 — Pronoun/adj. 2nd person plural</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>5 — Indefinite pronoun &quot;on&quot;</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>6 — Present tense</td>
<td>72</td>
<td>58.1</td>
</tr>
<tr>
<td>7 — Futur tense</td>
<td>25</td>
<td>22.1</td>
</tr>
<tr>
<td>8 — Perfect tense</td>
<td>2</td>
<td>8.1</td>
</tr>
<tr>
<td>9 — Imperfect tense</td>
<td>0</td>
<td>8.1</td>
</tr>
<tr>
<td>10 — Preterit tense</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11 — Conditional tense</td>
<td>1</td>
<td>3.5</td>
</tr>
<tr>
<td>12 — Temporal deictic</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13 — Auxiliary &quot;aller&quot; (to be going to)</td>
<td>12</td>
<td>20.9</td>
</tr>
<tr>
<td>14 — Aspect auxiliary</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15 — Modal auxiliary</td>
<td>13</td>
<td>5.8</td>
</tr>
<tr>
<td>16 — Auxiliary &quot;pouvoir&quot; (can)</td>
<td>6</td>
<td>9.3</td>
</tr>
<tr>
<td>17 — Passive form</td>
<td>1</td>
<td>4.7</td>
</tr>
<tr>
<td>18 — Emphatic form</td>
<td>1</td>
<td>8.1</td>
</tr>
<tr>
<td>19 — Non declarative sentence</td>
<td>12</td>
<td>4.7</td>
</tr>
<tr>
<td>20 — Temporal organizer</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>21 — Argumentative lex.snt. organizer</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>22 — Textual argumentative organizer</td>
<td>N/O</td>
<td>N/O</td>
</tr>
<tr>
<td>23 — Utterance modality</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>24 — Pronominal anaphora</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>25 — Non pronominal anaphora</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>26 — Verbal density</td>
<td>0.9</td>
<td>0.08</td>
</tr>
<tr>
<td>27 — Syntagmatic density</td>
<td>0.48</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Note. Bronckart's method works on French texts. We have translated the linguistic units but the reader should be aware that there is not a one-to-one mapping between French categories and English categories. There are some decimal numbers in the second column because of an adjustment to the same number of verbs as in the first column.
Table 1: Occurrences of the 27 linguistic unit in each discourse.

Students’ behaviour

We noted significant differences between students in Grenoble and students in Valence for 3 tasks among the 4 we observed. The listening time is longer in the distance situation ($Z = -3.36$, $p < .01$) as is the watching time ($Z = -2.1$, $p < 0.5$). On the other hand, dropping out time is longer in the traditional lecture ($Z = -2.42$, $p < .05$). There is no significant differences however for the time spent to take notes ($Z = -1.37$, ns).

If we group the listening task and the watching task into a new category called information collecting task, we can make new comparisons. We noted a significant difference between the two lectures for the information collecting task which is longer in the distance lecture than in the traditional lecture ($Z = -2.1$, $p < 0.5$).

Discussion

We should now interpret these results while trying to relate the teacher's discourse to the students' behaviour.

Students’ Behaviour

Results seem to indicate that the cognitive load is greater for the distance students: they are more attentive (the dropping out time is lower) and spend more time listening and watching the teacher. These facts are borne out by students’ attitudes: they seem to be in a state of concentration.

This can be explained by a restriction of the communication to its digital side. The digital side of a communication is all what result of a coding [Watzlawick et al. 1967], like the language for instance, and the analogical side is the rest (gestures, voice inflexions, etc.). Computerized distance education systems do not well reproduce the analogical side of teacher-students communication. In the system we studied, only texts and teacher's discourse are reproduced. Analogical signs such as teacher's gestures or teacher's positions in the room are ruled out. But these signs are used by students in traditional lecture to know what is important or not and to find opportunities to relax. For example, when the teacher leaves his platform and speaks with the hands in his pockets, then students attach less importance to what he says that when he writes it down on the blackboard. Distance students do no get these signs. Therefore they consider everything important and they cannot relax.

It is worth noting an experimental bias there: lecture rooms were not of the same size. The fact that students were more attentive during the distance lecture can be also put down to their greater proximity to the assistant who was in the room. In the traditional lecture room, students were more distant from the teacher, which is propitious to inattention.

Students' behaviour in Valence was reinforced by the teacher's discourse whose density did not encourage temporary dropping outs.

Teacher’s Discourse

Results indicate that the teacher's discourse for distance students is much more structured and denser. For instance, the occurrence of linguistic units such as argumentative organizers or pronominal anaphora, which are both indications of structure and coherence, is greater in the distance lecture. This can be explained by the fact that the teacher had to design the slides beforehand which had forced him to prepare in very details the lecture content.

Another reason is that since the communication has been restricted to its digital side, the teacher do not get signs that would have revealed students failing to keep up (eyes on neighbour, frowns, etc.) Therefore the teacher cannot adapt his discourse and confine himself in what was prepared. His discourse is then very authoritative.
In a time of proliferation of distance education projects, these results seem important to us. In particular, the higher students' cognitive load as well as the greater teacher's planning activity should probably imply modifications on the duration of classes within a day as well as the total duration over a semester.

Towards a New Model for Studying Teachers’ Discourses

As we said before, Bronckart's model is inadequate to discriminate globally the distance lecture from the traditional lecture. It would be interesting however to have a model that would characterize a pedagogical discourse on different media: book, computer, TV, videoconference, face-to-face, etc. For that reason, we decided to design the premises of a new model. The goal is to identify a set of morpho-syntactic units that would discriminate, at the beginning, our distance lecture from our traditional lecture. We saw that the important task of designing slides beforehand should result in a structured and coherent discourse. This hypothesis will lead us to look for linguistic units revealing this course planning activity.

We identified the following units:
1) Number of intra-textual connectives: subordinating conjunctions, coordinating conjunctions followed by a verb and other locutions linking up phrases: if, then, because, etc. All these elements reveal the discourse structure.
2) Sentence mean length: an indicator of the discourse planning (we used the following criteria for determining a sentence: a period is put every time two independent propositions can be cut without altering the syntax).
3) Delivery in words per minute. It is also a symptom of the mastery of the discourse.
4) Syntactic correctness rate: defined as the ratio between the number of sentences syntactically correct and the total number of sentences. This measure reveals a planning task prior to the course.
5) Number of redundancies: defined as the local repetition of a word or a group of words that do not provide additional information. A redundancy reveals a low planning but is also a natural way of trying to "rescue" students who would have temporarily failed to keep up. Therefore, the number of redundancies is expected to be higher in the traditional lecture.
6) Mean sentence interweaving level: calculated from the maximal level of proposition interweaving for each sentence. This is also an indication of the mastery of the discourse content.

We also added 4 of Bronckart's criteria. The following should characterize the live discourse:
7) Number of modal auxiliaries indication of the action of the speaker on the hearer.
8) Number of non declarative sentences for the same reasons.

On the other hand, the following criteria should characterize the mediatised discourse:
9) Number of lexico-syntactic argumentative organizers whose goal is to organize the discourse by means of textual markers.
10) Number of non pronominal anaphoras which contribute to the text coherence.

These 10 elements should discriminate the mediatised discourse from the live discourse. According to our hypothesis, we expect the values of items 1, 2, 3, 4, 6, 9 and 10 to be lower in the live discourse and values of items 5, 7 and 8 to be higher. Table 2 shows the results on our discourses.

<table>
<thead>
<tr>
<th>Linguistic units</th>
<th>Traditional lecture</th>
<th>Distance lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 — Intra-textual connective</td>
<td>58</td>
<td>51</td>
</tr>
<tr>
<td>2 — Mean sentence length</td>
<td>20.2</td>
<td>26.8</td>
</tr>
<tr>
<td>3 — Delivery</td>
<td>102.9</td>
<td>107.1</td>
</tr>
<tr>
<td>4 — Syntactic correctness rate</td>
<td>78.4</td>
<td>80.0</td>
</tr>
<tr>
<td>5 — Redundancy</td>
<td>18.5</td>
<td>12.1</td>
</tr>
<tr>
<td>6 — Mean sentence interweaving level</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>7 — Modal auxiliary</td>
<td>13</td>
<td>5.8</td>
</tr>
<tr>
<td>8 — Non declarative sentence</td>
<td>12</td>
<td>4.7</td>
</tr>
<tr>
<td>9 — Lex.-synt. arg. organizer</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>10 — Pronominal anaphora</td>
<td>11</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 2: Occurrences of linguistic units in our new model.
Except for item 1, this analysis seems to confirm our hypothesis that the traditional lecture and the distance lecture are inherently different. A $\chi^2$ test on items 1, 5, 7, 8, 9 and 10 indicates a significant difference ($\chi^2 = 23.04, p < .01$). However, this rough draft of a model should be tested on a lot of discourse in order to be validated. This will be part of our future work.

Conclusion

In this paper, we studied a distance education system. We showed that this system restricts the nature of information transmitted between teacher and students. Exactly like the O'Connail’s study we mentioned at the beginning of this paper, this alteration of the communication has an effect on the participants. In our case, the teacher makes a more authoritative discourse and students are more attentive. This is probably due to the elimination of the analogical part of the communication which permits all participants to adapt to the context.

At the end of the paper, we suggested the sketch of a model that could be used to highlight the differences between a mediated discourse and a traditional discourse.

Acknowledgements

We would like to thank Pierre Bailly who allowed us to video his lectures, Nicole Hermann who helped us in the experimentation and the Laboratory of Computer Science Engineering (L.G.I.) of the university of Grenoble who allowed us to use its morphological analysis system, PILAF, for analysing our corpus.

References


The rapid technological development in multimedia/hypermedia and network have led to the changing educational paradigms that we are currently experiencing. We are compelled to examine new ways of learning as made possible by the computer technology. Some of the characteristics of this new learning include more emphasis on simulating real-life environments and encouraging collaborative learning through the use of interactive multimedia technology. This paper reports the author's recent experience in engaging students in a collaborative multimedia design project.

This experience occurred in the teaching of a graduate level course of Interactive Multimedia: Design and Production. This course is offered to the students in the College of Education at the University of Texas - Austin. Students attending this course include teachers, educational technologists, and future instructional designers. It is designed with an intent to provide students with a learning environment where they can apply the theories of the multimedia technology into practice. To simulate real-world multimedia production and encourage collaborative learning among the students, students attending the course are asked to design and produce a multimedia-based informational kiosk for the College of Education collaboratively as a class. This kiosk is to be used by students, faculty, staff, visitors and alumni on the university campus upon its completion. This course has been taught for four semesters, and the kiosk project is in its final phase.

To facilitate this collaborative learning experience, a four-phase instructional model was used in each semester: (1) Phase I: Planning, (2) Phase II: Design; (3) Phase III: Production; and (4) Phase IV: Evaluation & Revision. This model was based upon Lehrer's instructional model [Lehrer, 1993] and models used with local multimedia developers [McDaniel & Liu, in press]. Through these four phases, students were engaged in the following tasks: (1) brainstorming about what to include and how to include; (2) searching for information; (3) designing surveys and interviewing people; (4) writing the scripts; (5) brainstorming about what visual materials to use for the scripts; (6) designing storyboards; (7) creating graphics; (8) shooting video; (9) taking pictures; (10) digitizing audio (music and voice narration) and video; (11) making video clips by incorporating music, voice narration, still images, and video scenes; and (12) putting all together into one program. The students were engaged in the design process from the inception of ideas to the finished product. Learning multimedia tools and applying what was learned in this creative process was essential for the kiosk development.

Several aspects characterized this collaborative multimedia design project. First of all, the classroom was simulated as mini-multimedia production house in which students assumed various roles of being a script writer, a video producer, a programmer, an artist, a project manager, or both at different times. Each week, students negotiated in the group the tasks they would carry out based upon the guidelines given by the instructor. Each student was responsible for a certain part of the project and his/her work would feed into the work of others. For example, some students would be responsible to shoot video scenes in public schools. Others would take the video scenes and transfer them into the digital format. Still others would use the digitized video scenes and make a Quicklime movie. Second, the design and production process was a group process from the beginning. The groups responsible for individual sections of the project met weekly in addition to the class meeting. The students communicated almost daily on-line through email and a local bulletin board system. All decisions of what to include and how to include were the results of group negotiation and group consensus. Students realized that multimedia development relied heavily on various talents in a group and the success of the project depended upon the constant communication and understanding between group members and their working together to reach the goal [McDaniel & Liu, in press].

The authentic aspect of the learning experience motivated many students because they perceived it as helpful to get them better prepared for the job market. The collaboration and interaction among groups enhanced students' understanding of the multimedia technology. Many students reported that the collaborative process was the most valuable and meaningful experience they have had.

Abstract: This paper reports our experience in engaging high school students in designing and producing multimedia programs for a real audience. It describes the instructional model used and the development process involved. Student-created programs are presented. Reflection on this learning experience is discussed.

Theoretical Assumptions

A distinction has been made between learning from computing and learning with computing [Jonassen, 1994]. According to Jonassen, learning from computer technology refers to situations in which computers are as tutors. Computers teach learners a concept or topic, and "direct the activities of the learner toward the acquisition of pre-specified knowledge or skills" (p.4). Learning with computer technology, on the other hand, emphasizes on using computers as cognitive tools to extend human minds and help learners to construct their own knowledge. One way to learn with interactive multimedia/hypermedia technology is to engage students in designing multimedia programs.

One of the major benefits of engaging learners as designers of multimedia programs is to promote Perkins' concept of knowledge as design [Lehrer, Erickson, & Connell, 1994; Perkins, 1986]. In such an instructional environment, learners, instead of merely receiving information from computers, become an intellectual partner with the technology and engage in constructive learning process [Salomon, Perkins, & Globerson, 1989]. The emphasis is on using multimedia tools to assist in processing information meaningfully, and integrating new knowledge with prior knowledge. As designers, learners are given the opportunity to be creative, and pursue actively their own intended goals. Seymour Papert says "Better learning will not come from finding better ways for the teacher to instruct but from giving the learner better opportunities to construct" (1990, p.3). Because of its nonlinear and associative characteristics as well as its use of various media, interactive multimedia is considered to be capable of assisting information presentation, representation, and construction [Nelson, & Palumbo, 1993] and capable of facilitating this learner-as-designer process [Jonassen, 1994; Lehrer, 1993]. Since designing a multimedia program incorporates a wide range of higher order thinking skills, and integrates a variety of activities [Carver, Lehrer, Connell, & Erickson, 1992], its comprehensive nature and extensiveness make it a unique learning opportunity. In the following, we will report our experience in the design and implementation of such a learner-as-designer environment for a group of inner-city high school students.

High School Students as Multimedia Designers

This class project was carried out in the Spring semester of 95 with a group of students from an inner-city high school in a mid-size Southwestern city. This high school has 31% Caucasians, 58% Hispanics, and 11% African Americans. About 45 percent of the students in the school are from low income families, 10 percent are qualified as Limited English Proficiency (LEP) students and approximately 60 percent of the population are considered to be at-risk for not finishing high school. The fourteen participating students characterized this student population. This project was designed to provide an innovative way for motivating the students. Ten male students and four female students participated in the project and the average age is 16.
The students were given the opportunity to work with a local Children's museum and design multimedia programs for young children. To facilitate this learner-as-designer process, a four-phase design model was used. This model was constructed based upon Lehrer's instructional model [Lehrer, 1993] and models used with local multimedia developers [McDaniel & Liu, in press]. It includes (1) Planning (2) Design, (3) Production, and (4) Evaluation and Revision.

At the planning phase, the students, first of all, visited the Children's Museum to get a sense of what exhibits worked for young children and what did not. The students filled out a survey which contained eight questions such as "What do kids do in the exhibit?" "What part(s) is/are the most interesting (or least interesting) for kids?" "Why do you think kids are interested (or not interested) in this part?" Then the students were engaged in the brainstorming and discussion sessions on what they saw at the museum and what they wanted to create. Many possible topics were proposed. After discussion and negotiation, considering their own interests, the interest of the museum, and time factor, students formed three teams with five students in two teams and four in one team. They decided to create a virtual museum with three different topics for the Children's Museum: a program on physics, a program on dinosaurs and another on history. Meanwhile they evaluated some commercially available multimedia CDs, noted and reported the features that they liked and the features that did not work well. The students also listened to the lectures given by some local multimedia experts on how to make a successful multimedia program.

At the design phase, students were engaged in defining and refining the topic, subtopics, the age level of the audience and strategies to use. The students went to the library to research and wrote up information to be incorporated in the programs. Each team was asked to create a storyboard, detailing how each screen was related to the other and the overall structure of the program. Each team member had chosen or was assigned a role of a researcher, a graphic artist, a programmer, a project manager, or an animator, depending on his or her background and the program's requirements. Some students assumed more than one role, while some took on different roles at different times.

During the production phase, the storyboards were prototyped on the computer. The students learned some of the state-of-art multimedia tools including Adobe Photoshop, and Macromedia Director. Claris Works and SuperPaint were also among the programs used. Although some students had knowledge of Claris Works and SuperPaint from previous computer classes, few knew Photoshop and Director. None had participated in a similar learning context before. Students had drawn all the graphics, recorded their own voices and created all the animation from the scratch, so as not to violate copyright laws. Then all the pieces were assembled into the final programs. Like the practice in the real world [McDaniel & Liu, in press], evaluation and revision phase was intended to be a dynamic and interactive process in that the programs were being evaluated on a continuous basis by team members, and members from other teams. Revisions were made immediately. Table 1 is a summary of the design model and activities related to each phase.

The Multimedia Development Process

The students met as a class everyday for 1 hour and half for eighteen weeks, a total of 135 classroom hours. Class periods typically consisted of whole class activities and group work. Examples of whole class activities included brainstorming sessions, lectures on multimedia design, instruction on multimedia tools, and field trips to local multimedia companies. Group work referred to students working in their own teams, storyboarding, learning multimedia tools, and creating their projects. In addition to the classroom teacher, a multimedia educator as well as a graphics artist from the Children's Museum worked with the three teams on a weekly basis. Both of the outside experts had extensive multimedia experience. At the end of the semester, students had an open house to demonstrate their programs to other students and local multimedia industry.

The students had access to two power Macintosh computers (about two months after the semester started), 8 Mac LC3s, 1 Mac 575, 1 Mac 520, a Cannon Xapshot camera, and a color scanner. The computer equipment was, however, spread in two separate rooms due to the constraints of physical layout of the classrooms. The two main programs used, Director and Photoshop, could only run on the two power Macs, the Mac 575 and the Mac 520 because of their large memory requirements. Students in the three teams, therefore, needed to share the available resources.
Because multimedia development is a complicated task and a new experience to the students, we have incorporated several factors in designing this learning environment based upon the concept of cognitive apprenticeship [Collins, Brown, and Newman, 1989]: (1) simulating the classroom as a mini-multimedia development house; (2) making the multimedia design process and the skills involved explicit; and (3) providing scaffolding to students in multiple ways.

Involving the students in developing programs for real audience helped to promote their intrinsic motivation for learning. Students were able to relate what they are doing to the real-world applications. The multimedia design process was made explicit in that direct instruction on design was provided by the teacher and local multimedia experts. The students had chosen a specific role to play, whether it was a programmer, a graphic artist, a project manager or both. They were engaged in brainstorming, storyboarding, researching, graphics creation, electronic photography, animation creation, and other activities related to multimedia development. The students had direct contact with their clients, the people from the children's museum. In addition, several trips were made to professional multimedia houses, user group meetings and university multimedia classes to learn and share their experience. Students were scaffolded through: (1) explicit design instruction, (2) learning multimedia tools, (3) coaching by the teacher, and the people from the museum and (4) interaction with local multimedia experts. The students were also asked to reflect on the design process in their response logs.

Table 1: Activities and thinking skills related to each phase of the design model

<table>
<thead>
<tr>
<th>Design Model</th>
<th>Activities Used</th>
<th>Thinking Skills Aimed at*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I: Planning</td>
<td>• brainstorming &amp; discussion</td>
<td>• posing question</td>
</tr>
<tr>
<td></td>
<td>• visiting children's museum</td>
<td>• deciding on the nature of the problem</td>
</tr>
<tr>
<td></td>
<td>• evaluating commercial CDs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• searching for information</td>
<td>• developing new information</td>
</tr>
<tr>
<td></td>
<td>• researching</td>
<td>• analyzing and interpreting information</td>
</tr>
<tr>
<td></td>
<td>• lectures by multimedia experts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• instruction by the teacher</td>
<td></td>
</tr>
<tr>
<td>Phase II: Design</td>
<td>• storyboarding</td>
<td>• creating a timeline</td>
</tr>
<tr>
<td></td>
<td>• research</td>
<td>• allocating resources and time to different segments of the project</td>
</tr>
<tr>
<td></td>
<td>• group discussion</td>
<td>• assigning roles</td>
</tr>
<tr>
<td></td>
<td>• learning multimedia tools</td>
<td>• deciding on the segmentation of information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• developing a structure</td>
</tr>
<tr>
<td>Phase III: Production</td>
<td>• learning multimedia tools</td>
<td>• developing representation through different media</td>
</tr>
<tr>
<td></td>
<td>• scanning photographs</td>
<td>• transferring the design into a presentation medium</td>
</tr>
<tr>
<td></td>
<td>• drawing pictures</td>
<td>• developing a structure</td>
</tr>
<tr>
<td></td>
<td>• creating animation</td>
<td>• juggling constraints (e.g. time, equipment etc.)</td>
</tr>
<tr>
<td></td>
<td>• digitizing audio</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• programming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• taking field trips to multimedia houses, user group meetings and university classes</td>
<td></td>
</tr>
<tr>
<td>Phase IV: Evaluation &amp; Revision</td>
<td>• peer evaluation &amp; revision</td>
<td>• soliciting peer feedback</td>
</tr>
<tr>
<td></td>
<td>• client evaluation &amp; revision</td>
<td>• articulating intentions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• public presentation</td>
</tr>
</tbody>
</table>

* These thinking skills are those listed by CarverLehrer and their colleagues [Carver et al., 1992].

Student-Created Multimedia Products
The software the students learned to use included SuperPaint, Adobe Photoshop, Macromedia Director, SoundEdit 16 for digitizing audio, Ofoto for scanning, and Cannon Xapshot camera for images. At the end of the semester, three programs were produced: (1) a history adventure, (2) a dinosaur tour, and (3) physics for five-year old. All of the programs were composed from scratch. That is, all components (graphics, audio, animation, video) were made by the students. The media used by all the groups included text, graphics, audio, and animation. Video was used minimally as the computers were not equipped to do high quality digital video. Figure 1 shows some screens from the three programs.

Figure 1: Screen Shots from the Three Student-Created Programs

The Dinosaur program was a game. It started with a user driving through a "Jurassic" like forest and into an ancient time when dinosaurs lived. It was intended for 9-13 years old children. It has three sections: (1) a picture show where a user learned about dinosaurs; (2) a game where a user guessed dinosaur names, and (3) a test where a user encountered a series of questions about the content of the program. The Physics team used a discovery approach for young children to learn how the gravity worked. Like the dinosaur project, it also had three parts. The first part featured a cartoon character that would throw a variety of objects from a roof of a building upon a user's choice. Every time an object was thrown, the cartoon character would explain the physics involved. The second part was about the effects of gravity on a pendulum. The third part examined the effects of momentum on suspended metal balls. Animation, text and audio were used to illustrate all three concepts. The History adventure contained the most complicated content of all. It covered Pirates of the Caribbean, War of Roses, and King Tut's Egypt. The students learned, on their own, a 3D modeling program to create a three-dimensional museum room for young users to browse. There were paintings on the wall that a user could click and obtain further information of the painting and its historical age. The initial video for motivating students to learn history was creatively done. It showed that a students went to sleep while studying history. An elf stole his history book and the student chased him to recover the book. The scene ended in an museum exhibit where the
student could explore and look for the missing items (supposedly stolen by elf) from different periods of the history. In analyzing these programs, the teacher made the following comments [Tab. 3].

Table 3: Teacher's Comments on the Student-Created Programs

<table>
<thead>
<tr>
<th>Programs</th>
<th>General Comments (regarding content, structure, creativity)</th>
<th>Screen Design (regarding font, color, navigation)</th>
<th>Use of Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dinosaurs</td>
<td>• content was appropriate for the intended audience (i.e. 9-13 year-olds) • various topics about dinosaurs were presented and a quiz was used to check a user's understanding of the topics • the idea of navigating through a forest to find dinosaurs was not novel • the program has few programming bugs</td>
<td>• the screen design was clear and engaging • colors were used appropriately to give a sense of travel through a Jurassic forest • navigation was easy • 18-24-point fonts were used for easy reading • voice as well as graphic were provided for all answers the questions in the quiz were too many objects were at the same time and the speed suffers accordingly • the graphic design of each section was consistent with overall theme and the graphics were richly drawn and appropriate for the project</td>
<td></td>
</tr>
<tr>
<td>History</td>
<td>• although text and audio was, in general, appropriate for the audience (i.e. 8-12-year olds), some of the vocabulary used appeared to be too difficult for this age group • the content was appropriate for an introduction on the topic and no in-depth exploration of the topic was provided • the project shows students' creativity in the overall design</td>
<td>• the navigation was easy as every screen has the same interface with navigation buttons placed consistently in the same spot • color was carefully chosen and most of fonts used were readable • the interface of the program was sophisticated as the graphics were elaborately drawn. Each historic time has appropriate graphics • the interface of the program spent extraordinarily amount of time on the appearance of the project • while visually pleasing, the graphics for program have many programming bugs due to lack of time for testing and revising</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>• as it is designed for 5-year olds, the content is simple, and the concept of gravity is presented through different scenarios • the program was completed on time and was debugged thoroughly</td>
<td>• graphics were simple and the interface is clean • for the gravity building, when a user moves a mouse onto an object, the object blinks to prompt a user to click • text is often accompanied by audio for presenting the information as audio is very important for young children • animation is heavily used to illustrate the concept of gravity</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation on the Learning Experience
The students exhibited strong motivation in this multimedia development experience. They increased significantly their on-task behavior and the amount of time spent working on the projects [Liu & Rutledge, 1996]. Many students spent their lunch period, time before and after school working on the project. Some students took work home, some came early in the morning, and some spent their spring break and Easter weekend working on the projects. Students' interest in this experience was reflected in such statements as "It [working on the project] is good for our education," "The experience is important. And it could help us get jobs," "This is just something that I like to do. [It] will be real help in the long run," "It [the class] prepares you more for the future." That is, students felt that the experience was valuable as it prepared them for the job market. They saw relevance in what they were doing. It was quite obvious that the real-world implication of the task and its usefulness to the future became important motivational sources.

To reflect upon the learning experience, students were asked to write response logs three times: once at the beginning of the semester, once at the mid-semester and once at the end of the semester. One of the questions in the response logs was for students to describe what and how they would do if they were given the task of designing a multimedia CD for a company. Students' responses at the end of the semester showed that they had a better understanding of the multimedia design process. Table 2 is an example of the responses from one student.

<table>
<thead>
<tr>
<th>Responded Before the Class</th>
<th>Responded After the Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>• find out the best equipment, the fastest W.O.R.M., the fastest computer, the best CD-ROM</td>
<td>• hire programmers, artists, writers and designers</td>
</tr>
<tr>
<td>• find out the best programs and buy them</td>
<td>• brainstorm for ideas</td>
</tr>
<tr>
<td>• produce CD and market it</td>
<td>• organize ideas and put into storyboard</td>
</tr>
<tr>
<td>• produce CD and market it</td>
<td>• create the program (i.e. designing graphics programming, writing scripts)</td>
</tr>
<tr>
<td>• put the program together</td>
<td>• put the program together</td>
</tr>
<tr>
<td>• preview the program</td>
<td>• press the CD and send it out to the market</td>
</tr>
</tbody>
</table>

The students improved their understanding of multimedia design. The tasks needed for planning and design, which did not exist in the first response log, were included in the last response log. The process many students described reflected the design model with which their learning experience was based upon. It appeared that the students had internalized some of the design skills toward the end of the semester. It was also obvious that for many students, planning and doing storyboards were very difficult. They were eager to work on the computers. However, by working closely with people who had multimedia experience such as the multimedia educator and the graphic artist from the children's museum and by interacting with multimedia professionals through the field trips, the students came to understand the importance of planning and designing before the production. They observed how storyboards were used by the professionals, and had a first-hand experience of using storyboards. They changed from being impatient and reluctant in doing storyboards to readily using storyboards. Complaining about doing storyboards were replaced by a desire to do better and more detailed ones.

It is clear that the students had benefited from this learner-as-designer experience. However, we face many more challenges. As multimedia design is a very complicated process, allocating appropriate time for each task has not been easy for the students. More assistance should have been provided. We also realize that it is important to provide continuous support to the students who are inspired by the experience and encourage them to pursue their active learning. Engaging students in designing multimedia programs offers a new way of learning. The challenge is to continue to search for ways of designing learning environments that foster knowledge construction with multimedia tools and facilitate knowledge transfer to other learning contexts.

References


A Computer-Based Tutor for Teaching and Learning Word Problem-Solving

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Abstract: WoPST is a computer-based learning environment designed to teach word problem solving to 9-12 year old students in Singapore primary schools. The students are taught to solve word problem solving using a locally developed approach called model building. Students will draw blocks to represent part-whole relationships depicted in the problem statement, and by drawing such blocks, they can visualize the problem more clearly and are able to make tacit knowledge explicit. The design of WoPST is based on some of the teaching methods of the cognitive apprenticeship approach. In this paper, we describe how these teaching methods have been implemented in the current version of the tutor.

The Domain: Word Problem Solving for Students using Models

Word problem solving is a major part of the curriculum in Primary 3, 4, 5 and 6 (9-12 year olds) mathematics in Singapore. It requires pupils to tackle mathematical problems encoded in situations such as the following:

Tom, Jack and Lawrence need to settle a bill of $84 after a dinner. If Jack pays twice as much as Tom, and Lawrence pays twice as much as Jack, how much does Lawrence pay more than Tom?

The word problems are designed to depict real-life situations such as grocery shopping and division of money. In schools, pupils learn the use of models as a means to solve word problems. They draw mathematical models (or blocks) to capture the relationship given in the problem. For the above problem, pupils will first of all draw:

Using the above model, pupils can then easily work out and find the final answer, $36. The technique of model building is an abstract way of picturing a situation. Instead of forming simultaneous equations and solving for the variables, model building involves using blocks or boxes to solve the problem. By drawing blocks, students can visualize the problem more clearly and are able to make tacit knowledge explicit. The power of using models can be best illustrated by problems, often involving fractions, ratios or percentages, which appear difficult but if models can be drawn to show the situation, the solution becomes clearer. Here is an example:

Class A and class B have the same number of pupils. Class A has twice as many boys as Class B. Class B has 3 times as many girls as Class A. Find the ratio of the number of girls in Class A to the number of boys in Class B.

\[1\]

Problems like this can be solved using variables, but this is precisely because students have problems with the concept of variables that model-building ("pictorial algebra") is introduced to Singapore schools.
The model-building approach to solving word problems was developed locally about 10 years ago by Hector Chee, a very experienced mathematics school teacher. Students here typically find word problems difficult due to various reasons: they are weak in mathematical language; they have limited understanding of the arithmetic operations; they are unable to relate knowns and unknowns when the problem structure is difficult; and they are unable to analyze problem situations. In this project, we seek to develop a computer-based learning environment that helps the student to learn solving word problems.

The model-building method to solving word problems differs from solution methods used in other computer-based word-problem solving tutors. For example, TiPS is designed to support adolescent and adult-problem-solving using a schema-based approach [Derry et al., 1994]. TiPS provides five such schemas which represent typical patterns or set relationships that can be found in arithmetic word problems. The user solves problems by selecting these primitives to construct a solution. Schemas like these might still be too difficult for 8-12 year old students to comprehend and use. The ANIMATE system [Nathan & Resnick, in press] uses a graphical arrangement of nodes and arcs to organize the information in word algebra problems. Nodes serve as placeholders for numbers and unspecified variables extracted from the problem statement. Arcs denote the relations among nodes (such as $+, -, \times, /, =$). A horizontal or vertical sequence of nodes and connecting arcs represents an equation. This solution method seems appropriate for problems involving averages, rates and speeds.

**Instructional Approach Adopted**

We base our design of Word Problem Solving Tutor (WoPST) on the teaching methods proposed in cognitive apprenticeship by Collins [1991]². Cognitive apprenticeship is the deployment of apprenticeship in the process of learning [Brown et al., 1988]. It emphasizes cognitive skill, the mental process of learning. The approach consists of six teaching ways to promote the development of expertise:

- **Modeling and Explaining:** Modeling is the showing of how a process unfolds and involves giving reasons why it happens that way. Showing and telling form the core of apprenticeship.
- **Coaching:** The expert coaches student by providing hints and feedback, and assisting them to perform closer to his standard of skill. In the context of a computer-based learning environment, the computer system has the ability to patiently monitor the students by recording and analyzing what the students have done. It can further provide hints or assistance when requested by the students.
- **Scaffolding:** The expert assists the student to manage task performance by completing those parts of the task that students have not yet mastered. Scaffolding is coupled with fading, the gradual removal of the expert’s support as students learn to do more of the task on their own.
- **Articulation:** Articulation refers to methods for forcing students to explain and think about what they are doing. Through this process, students would be able to consolidate what they have learned.
- **Reflection on Performance:** Reflection on performance provides an opportunity for the students to look back on what they have done and analyze their performance. Comparisons between peer performance or with that of expert performance could then be carried out.
- **Exploration:** Exploration allows the students to try out different hypotheses, methods and strategies to see their impact on the model they are working on. This puts students in control of problem solving and provides room for the inquisitive minds.

**Word Problem Solving Tutor**

²While we have applied cognitive apprenticeship to word problem solving which a non-authentic domain, we hope to find out the extent of the suitability of its teaching methods in a domain for 9-12 year olds’ kids. For example, we would like to explore whether young kids find reflection useful in helping them to learn solving of word problems.
In our current implementation of WoPST, we developed several core modules including “Model Solution”, “Coaching”, “Reflection” and “Exploration.”

Model Solution
In “Model Solution” module, WoSPT models expert or teacher performance when solving a word problem. Phrases in the problem statement are highlighted to show that the expert is currently working on that part of the statement before a corresponding partial model is drawn. The complete model is then gradually drawn with each succession of highlighted text. With this alternation of problem statement highlighting and model drawing, the student is able to see how relevant data from the problem statement is extracted and used to construct the model by an expert. After a complete model is built, arithmetic calculation will come into play. To arrive at the final answer, the student usually needs to perform a few intermediate steps. In “Model Solution”, the student clicks the “Next Step” button to observe how each of the intermediate steps is derived from the model. Short statements accompanying these steps further explain to the student how the intermediate steps lead to the solution. Figure 1 is a screenshot of WoPST that shows a model solution.

In this module, students learn how to solve a problem in a systematic way like an expert. The school teachers we worked have highlighted that students often stumble on the very first step in the solving process. The modeling of expert performance in this case will be beneficial as students could see how an expert gathers information in the beginning before solving a word problem. Demonstrations on chalk boards or books have their inherent limitations. Many class demonstrations occur too fast for the student to assimilate what is happening and why it is happening. In books, worked-out solutions use static diagrams and text explanation to illustrate the solving process. Due to space constraints, intermediate diagrams are often omitted to make the solution terse. The ability at one’s own pace to see how the construction of model unfolds and how the final answer is derived helps to build an integrated understanding of the solving process.

Coaching and Scaffolding
For a student starting to pick up the technique of model building, it is always good to have a tutor who looks over her shoulder and readily gives guidance whenever she encounters difficulties. In the “Coaching”, we adopt the “follow-me” style in which the computer will give a prompt (highlight some text in the problem statement or
ask a simple question) and the student is required to either build a model\(^3\) or do some calculations in response to the prompt. These intermediate answers are then evaluated and relevant feedback is given to the student.

Throughout the coaching process, when the student encounters difficulties in a particular step, she can click on the “Tips” button for hints. By observing the student in a problem-solving situation, WoPST keeps track of the steps already performed by the student. As a result, relevant and specific hints can be given when a student fails in a particular step. In classroom teaching, teachers rarely have a chance to observe student’s problem solving process and most of the help they give is not really directed at the problems the students actually have. At any step in “Coaching” during the model building process, students can do as many steps as they like. This allows students to break away from the rigid “follow-me” style and encourages them to think ahead. The student’s answer is then evaluated and the next appropriate step is subsequently prompted. We use incremental diagnosis in which the model is dissected and examined in parts or in steps. When an error is encountered in the model, the evaluation process stops and relevant feedback will be given. Figure 2 shows a screen of WoPST in which coaching advice is given to the student. Student modelling is done in WoPST on a local basis by keeping track of the models drawn by the student for its correctness, and then deciding what hint or scaffold to provide to the student [Hawkes & Derry, 1995].

![Coaching screen](image)

**Figure 2. Coaching screen**

In WoPST, we have implemented 2 levels of coaching with one level giving less guidance than the other. The reason for having this is to gradually take away assistance as the students become more proficient in model building. In Coaching Level 2, steps in Level 1 are combined or skipped so as to limit the degree of assistance.

Coaching enables students to do tasks they might not otherwise be able to complete. It gives them a sense of achievement when they can solve difficult problems with the help of some advice. As students become more skilled, the coach’s role will fade and students are likely to be less dependent on the hints and help given in coaching.

**Reflection on Performance**

In “Practice”, the student is on her own and no help is available throughout the problem-solving process. We realise that some students may encounter difficulties in some questions and are eager to find out the correct way

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\[1\] WoPST provides a graphic editing tool to build models. To help us build the tools, we analyse how students draw models by observing them as well as looking at their workbooks. We also conducted a few usability sessions on our initial versions of the tool in order to ensure that the tool is easy to use.
of doing it. For them, we provide a link between the "Coaching" and the "Practice" modules such that a difficult question in "Practice" can be readily brought back for coaching. After a problem has been tackled by the student, she is given the opportunity to compare her model to that built by a teacher. The student's model and the expert's model are displayed side-by-side on the screen for easy comparison. In this way, the student would know whether the models they build are similar to that of the expert's. They may even realize that their model can be built more optimally or in another way. This reflection on performance encourages students to think about their solving process from the point of view on how they might be different and what changes would lead to improved performance.

![Image of a problem statement and solution]

Figure 3. Screen which allows student to see her own solution vis-à-vis other solutions

** Exploration **

Most of the time, the student is given a problem statement and asked to build the corresponding model. This conventional way of give-question-and-ask-for-answer approach offers little exploration opportunity to students. To break away from this, we have designed the "Exploration" module in which a problem statement together with its model is given, and students are allowed to change the keywords to see how the change affects the model. The keywords that can be changed express relationships like "twice as much as", "half of", "same as" and the like. This puts the students in control of the type of relationship they want to create in the problem. They will feel the joy of generating their own ideas and seeing how the change is reflected in the model. Figure 4 shows an "Exploration" screen after the student has changed a keyword phrase in the problem statement.
Evaluation and Future Work

We are currently extending the exploration module to provide a two-way Problem and Solution Editor (PSE). PSE allows new problems to be created and existing ones to be edited. It can be used by the teachers or the system developers for adding problems to the problem database. PSE allows the student or teacher to edit a problem, and observe how the solution gets automatically changed in the process. Vice versa, the student or teacher can alter the solution, and observe what changes are made automatically in the problem statement to reflect the changes. We will also provide further support for the student’s “Exploration” process by providing an environment for the student to create his own word problems by filling in and selecting sentences from templates like:

Mary has _____ stamps.
Ann has _____ stamps.
Jenny has _____ stamps _____ than Mary.
Betty has _____ as many stamps as _____.
How many stamps have _____?
How many stamps do they have at all?
How many _____ (more/less) stamps have _____ than _____?
Find the average number of stamps each boy has.

The student can then solve his own word problem or watch the system solve it.

An early version of WoPST has been evaluated by 12 10-year old students from two local schools. The students were quickly acclimatized to the user-interface and starting going through the various modules in the software. They enjoyed using WoPST to solve word problems. We are now in the process of extending WoSPT to cover a wider range of word problems. WoSPT will also involve teaching strategic problem-solving strategies. We will conduct a formative evaluation of the current version of WoPST in March-May 1996.

Conclusion

We have designed a computer-based environment WoPST which harnesses the power of computers to empower the student to learn and explore word problem solving. At the same time, the environment can also enable the teacher to create new word problems with ease. WoPST has been designed by applying teaching methods from the cognitive apprenticeship approach. WoPST has a good potential of supporting thoughtful practice by the student by enabling her to engage actively and reflectively in problem solving, and of providing informative feedback to students about their performance.

References
Acknowledgments

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Abstract: Unspecialized formal language can be used to express technical knowledge in a precise but readable way. The greatest expressive simplicity results if the language uses the simplest possible units of information to model its subject matter. Those arrow-like objects provide a permanent optimum choice in the same sense that wheels should be round, pillars should be vertical, chains should have equal strength links, etc. The result can lead to a "universal language supporting technical literacy". Presenting knowledge in pre-integrated form can by-pass much learning effort. Creativity is enhanced by favoring the expression of reasonable hypotheses and exposing unnecessary complexities.

Learning to work carefully with various kinds of information is a pervasive activity in education. Working carefully with anything requires control over its fine structure. Those considerations alone are sufficient to make understanding of the fine structure of information a natural priority for educators and their students. The foundation of almost every field of science and technology consists largely of knowledge about the fine structure of its subject matter. The quality of almost all artifacts is strongly affected by the quality of their component microstructures.

Simplifying information microstructures makes it possible to combine many of the advantages of formal language and natural language. The result can be used to improve communication in a wide range of technical subjects. Such language can be very enduring because maximum simplicity of expression is being approached [Lowry 1991]. There will be very little further simplification in a statement such as:

\[ 82 = \text{count element where some isotope of it is stable} \]

A New Simple Irreducible Structure Optimum

The simplest possible primitive data objects make possible the greatest possible simplicity of complete description regardless of subject matter. The simplest objects that work are directed arcs (arrow-like objects, some of which point to themselves).
The engineering optimum is based on an irreducible structure, not a tradeoff. Similar optimizations lead to: round wheels, tubular pipes, vertical pillars, flat personal mirrors, etc. The optimization is stopped by a mathematical boundary. There is no way to be rounder than round, flatter than flat etc. In each case there is a structural feature of the optimum which is insensitive to at least small variations in conditions. There are about 25 such cases which are simple enough that the optimum structure contains no parts connecting other parts. In almost all those cases the optimum structure remains insensitive to variable conditions across a very wide range of conditions. They also share other striking characteristics. They get broad and enduring acceptance. They tend to have large social and economic value. They tend to become a part of everyday life. The directed arc data object appears to be a new one and will probably fit the pattern.

Evidence supporting the optimality is 100% supportive. It can be shown that: for sufficiently large deterministic languages of a given size, those which provide maximum simplicity of expression across any sufficiently evolving set of applications must only use data objects which are unlabeled directed arcs exclusively. Empirically, the theoretical optimum applies broadly to technical descriptions developed either for computer execution or human understanding.

In almost all simple irreducible structure optima, even small deviations from the optimum structure are unreasonable when the engineering requirements are demanding. It is all right for a tent pole to slope away from vertical, but not a pillar holding up a tall building. Similarly, simple information can be safely represented in a variety of ways, but rich information structures are unreasonable unless represented using only the simplest possible information objects.

The results are harmful for almost all knowledge workers, and students more than most. Current information technology is ill-suited to education because it is:

- very complex, the manuals tend to be larger than the students' textbooks.
- deficient compared with what was known 20 years ago, from the view that excess complexity is the main problem with technical information.
- ephemeral, much of it will not be useful after graduation.
- based on "square wheel" information components.
- needlessly ineffective for representing the structure of technical knowledge.
- pervasively damaging to the quality of technical symbolic information:
  ◊ its accessibility

![Directed arcs representing a simple relationship](image)
its usability
its clarity
its cohesiveness
and sometimes its accuracy.

Language Generality

The optimum choice of primitives can largely eliminate a longstanding separation between general purpose and special purpose language. Functions operating on directed arcs from any domain are easily merged into one language. While special purpose language features are needed, they can be much more easily expressed as superficial extensions to the more general purpose language. Very general language reduces barriers to accessing unfamiliar technical knowledge by reducing need for preliminary language learning. It allows for early learning of parts of the language and then using it to support any subsequent technical learning.

Directed arc data objects can provide a natural standard for the permissible structures for subject matter of technical language. After the underlying data structure issues are decided, a complete semantics of simple expressions for referencing and manipulating data substructures follows fairly naturally. Additional standardization could lead a durable foundation for a universal language supporting technical literacy.

Shannon Operators

Up until now there has been a very stable set of functions used in programming languages including:
  arithmetic including comparisons
  boolean operations
  set operations
  matrix operations.

They have very broad application and stable definitions. The optimality of directed arc data objects suggests that an expanded and more integrated set of functions can be defined which can have similar breadth of application and durability.

From formal languages which are at least somewhat unspecialized, it is possible to select groups of functions which operate on simple structures and which do not embody real world knowledge. They can form a language kernel which could be referred to as the “Shannon operators”.

Such groups include:
• creation and deletion of objects and relationships.
• getting objects directly connected to or related to others
• arithmetic operations including comparison
• test for identicalness
• boolean operations
• conditional and case expressions
• unique selection based on key relationships
• subsetting by a selection condition
• subsetting by beginning or ending conditions
• set operations for union, intersection, difference
• testing sets for membership, inclusion, or overlap
• applying a function to each member of a set
• reduction, applying a binary function successively to the members of a set and the preceding result
• transitive closure
• sorting sets
• operations on sets of sets
• first order predicates over sets
• matrix operations
• relational algebra operations
invocation of functions derived from the above

So far, attempts to produce general purpose languages have not succeeded in incorporating all of these in a satisfactory way. The simplicities gained by using directed arc data objects make it practical to do so. Almost all have been incorporated into KEEP [Van Horn 1985], a predecessor of Shannon.

Roles for the Language

Computer hardware and software can enhance the usefulness of the language but computer assistance is NOT initially a requirement. Such language can serve to assist students in a variety of their basic needs:

- to access readable expositions for many mathematical, scientific, and engineering concepts.
- to communicate effectively with their teachers and others.
- to easily articulate precise descriptions of complex ideas, enhancing their creativity and problem solving ability.
- to increase productivity through easily learned and used computers and other technical equipment.
- to help measure learning through tests which can be automatically marked but avoid the limitations of multiple choice questions.
- to provide a standard of information quality.

The language could assist educators in:

- presentation of technical concepts.
- designing exercises and tests.
- using, preparing, and adapting software for:
  ◊ exposition
  ◊ testing
  ◊ analysis of student responses
  ◊ administration.

Optimum data objects provide powerful operations and a declarative style which allows learning to be incremental and less regimented. A natural language style results which can help build on previous learning.

The total explicitness provides confidence that mysteries can be resolved. Automated analysis tools can speed the resolution. This can be particularly valuable when teachers are unavailable or only accessible remotely.

The earliest student exposure to the language could take the form of using it to manipulate toy environments using computers. Later it would be used to communicate well established mathematical and scientific ideas to the student. Learning to read the language is easier than learning to write it, so it can be used to explain before proficiency in writing it is developed. At a later stage the emphasis would shift to developing, and testing models. The ability to develop models which are integrated over large areas of subject matter can contribute to the efficiency of mental effort.

Computer analysis of knowledge prerequisites implied in the declarations could help people get oriented quickly in subject matter which they are unfamiliar with. They could then solve problems successfully in technical areas for which their background is limited by selecting only the information which is relevant to their immediate needs. Such analysis could also help students get oriented quickly when they fall behind. This capability makes it increasingly practical to postpone learning of technical details until there is a need to know them. As the overall body of technical knowledge expands, such capability becomes more necessary.

Pre-integrated Knowledge

A set of declarations describing the structure of a technical subject tends to be brief. It has obvious internal consistency which can be checked mechanically. It tends to circumscribe the possibilities under discussion rather tightly. The declarations significantly combine the clarity of natural language and diagrams with axiomatic rigor and comprehensiveness. They effectively summarize many possible diagrams made from directed arcs. Within such a framework, questions and creative hypotheses can be easily expressed. Many unreasonable hypotheses
would be automatically screened out. The questions and hypotheses can have a fairly informal style but still be precisely interpreted within the given framework of declarations.

This is very different from conventional presentations whether they use mathematical axioms, natural language statements, graphic images, or combinations of those. Mathematical axioms tend to be brief, but their consistency and implications tend to be so obscure that they are used with great difficulty or for very simple systems or they are used in conjunction with less formal expressions. The less formal expressions have much ambiguity which requires that they be re-expressed in a variety of ways and that their meaning be clarified with examples and graphic images. These conventional presentations all use many pieces of relatively fragmentary information which impose a large burden of consistency checking and integration on the student. A major benefit of the language would be the ability to communicate "pre-integrated knowledge" to the student in a way that reduces such burdens.

Creativity

Use of related formal language tools has contributed to some unusual discoveries. These include the optimum data objects and one of the few clear pictures of a fundamental physical phenomenon.[Lowry 1960].

![Fig 2. A charged particle and its classical electromagnetic field in space-time](image)

Evaluation

Quantifying the benefits in school settings is a fairly large undertaking. A useful initial step would be to verify that the directed arc data object is an irreducible structure optimum in a class with the invention of the wheel. If so, its careful evaluation in a variety of roles is more easily justified.

The best available evidence supporting more serious evaluation may be the creativity that it has already produced as described above. It provides a measure of the power of intellectual tools which can be made widely available.
References


Appendix: Elementary Chemistry in Shannon

<<declare chemistry domain  
   /* a partial system description independent of computers */
declare element list
   has id(hydrogen, helium, lithium, ... )
   has atomic_weight in number
   has atomic_number in tally

declare atom set
   has element

declare mass quantities
declare volume quantities
declare temperature quantities

declare molecule set
   has compound
   has set atom

declare compound set
   has id(carbon_dioxide, water, molecular_oxygen, ozone, ... )
   holds set component
   has set portion converse
   has molecular_weight in number := sum for its component take
   its tally * atomic_weight of its element

declare component sets
   has element key
   has compound converse
   has tally
   has fraction in number := its tally *
   atomic_weight of its element / molecular_weight of its compound

declare portion set
   may have compound
   has state_of_matter
   has mass
   has molecule_count in tally
   may have temperature
   may have volume

declare state_of_matter set
   has id(solid, liquid, gas)

decclare transformation set
   has set input in portion
   has set output in portion
   maybe decomposition := count(its input) = 1 and count(its output) > 1

certify some number satisfies every portion where gas satisfies
   its pressure * its volume / its temperate = the number
   /* the gas law */

certify every decomposition where compound of its input is sulphur_dioxide
   satisfies mass of its sulphur output = mass of its oxygen output >>
Abstract: Current Multimedia improvements could prove of increased value for Computer-Aided Learning if integrated into a global process for designing educational software.

Integrated Courseware Engineering Systems (ICES) can satisfy this integration aim. They provide adequate means of cooperation between the different actors (pedagogues, instructors, software engineers, ...) thanks to specific methodologies based on prototyping (spiral life cycle). The tools built with such methodologies can therefore provide the users with capabilities of reuse, or with guidelines for integrating HCI design into the global process.

We apply the principles of design promoted by ICES to develop an environment for educational software specification. We have defined several types of pedagogical objects (abstract and concrete objectives, educational tasks) which are stored in a toolbox. The pedagogues reuse these objects during the step of specifying educational considerations and during the prototyping of these considerations. Thanks to that toolbox, the pedagogues can be supported during the use of the specification method; they can also evaluate educational prototypes built from their specification.

Introduction

Reviewers, computer science journalists and CAL researchers agree on writing that we are entering an educational new-age relying on computers, multimedia and self-learning. In such an analysis, multimedia technology plays the leading part: it is used as a means of reaching knowledge through presentation and query mechanisms which are at the user's disposal. Encyclopaedic CD-ROMs and WWW servers are thus presented as powerful self-learning environments [Flisi 95]. We can then wonder whether multimedia technology could become the appropriate tool for "Just-in-time open learning".

Pedagogues and specialists in didactics are very cautious about the reality of this educational new-age. In fact, we are quite suspicious in front of this idealistic view of education because it is based on the hypothesis that a man (or a child) can learn anything and can structure his knowledge provided he can access motivating sources of information. A lot of pedagogues think on the other hand, that multimedia technology is only an appearance that pedagogical choices and didactic trends must enhance. In a recent conference, we were surprised with the reactions of different attendees after two communications:

- one aroused their interest as it described various pedagogical experiences proposed from a spreadsheet. These experiences did not rely on multimedia technology and multimodal interfaces at all but there were concrete pedagogical ideas focused by the computer tool.
- the other, presented by the chairman of an important multinational company, initially impressed the audience because the multimedia tools that he described had avant-garde features in the domain of video-conferencing for schools. When we analysed this speech later on, we noticed that this kind of communication was poor in terms of education and was playing on a confusion between educational improvements and technological ones.

More generally, we think that it is necessary to define the scope of multimedia in education more accurately so as to:
• take better advantage of the facilities that multimedia technology provides (information retrieval, information presentation ...),
• help the user become more responsible for his progress (just-in-time learning) as well as cater for his necessary assessment and coaching.

Integrating multimedia points of view in the process of designing educational applications is a complex activity which requires the cooperation of different experts: pedagogues, learners, software engineers and also specialists in ergonomics, didactics, video animation, etc... This requires specific methods and tools that we shall study in this paper through the concept of Integrated Courseware Engineering Systems [Nodenot 92a].

Firstly, we shall describe the principles and features of Integrated Courseware Engineering Systems (or ICES), focusing on two topics: the methodological aspect and the prototyping aspect. Next, we shall explain how these aspects are taken into account in the context of a particular development stage of educational software: the specification stage. Lastly, we shall present the specification environment principles that we are developing.

ICES: Principles and goals

The same rationale lies under Integrated Project Support Environments (IPSE) and ICES. These two kinds of systems come from the need of enhancing the development of software applications, namely educational software. They are based on the idea that different experts must cooperate to produce high quality software. In an IPSE, analysts, designers and programmers must aggregate their abilities. In an ICES, pedagogues, specialists in didactics, computer scientists and instructors have a similar role. Information exchange between the actors of such environments relies on a data repository. The repository is used during the whole software life cycle, from specification stage to maintenance, via the design and implementation stages.

The underlying hypothesis of these two kinds of environments is that the main design decisions have to be made as early as possible in order to limit the costs of changes. The actors are assisted in their choices by a tool supporting method; tools communicate through the data repository.

However, there are radical differences between ICES and IPSE. In an Integrated Courseware Engineering System, major decisions are made by pedagogues, not by computer scientists. The first stages of the educational software life cycle are therefore exclusively pedagogical; this basic characteristic has several consequences on the tools provided by the system. These tools must allow the pedagogues:

1) to formalise pedagogical considerations. This implies that the system provides pedagogues with some models and/or theories belonging to Educational Science, and possibly with means of creating their own models,
2) to make inferences on the models described by the actors in order to control their consistency and assist the pedagogues with their decisions. Artificial Intelligence tools [see 1] therefore need to be integrated into an ICES,
3) to present the different elements stored in the data repository in a convenient way. Pedagogical components, advice and coaching facilities must be provided via an appropriate interface (natural language, symbols and graphics, animation, ...).
4) to consider the learner as a full actor in the life cycle process. The pedagogues must adopt a user-centred design approach [Stanchev 95] in order to adjust knowledge transmission to different kinds of learners. Besides educational considerations, the presentation of the information provided to the learner is therefore very important. That is the reason why the actors of an ICES must pay particular attention to the design of multimedia / multimodal interfaces [Beltran 91].

These different points show that educational science, software engineering, multimedia / user-interfaces, and artificial intelligence are closely linked in an Integrated Courseware Engineering System. In the following paragraphs, we shall consider their relationships and focus on two points: the "method" and "rapid prototyping" aspects.

The Method Aspect

[1] This is not ICES-specific because in a process-oriented IPSE, such functionalities are available. They allow to control that some conditions are satisfied at the beginning or at the end of tools enaction.
The activities of the different experts who play a role in the process of developing educational software are tightly related [Nodenot 92b]. Research results in software engineering and courseware engineering showed that the only way of mastering this connectivity was to design method-oriented systems which are environments built around an explicit and formalised methodology. Within the scope of an ICES, several issues are to be considered:

- the methodology must allow the pedagogues to link pedagogical models (goals and strategies from educational science) and those which describe interaction scenarii between the learner and the system [Adam 95],
- the methodology must allow software engineers to re-engineer the models provided by the pedagogues in order to implement professional software applications using reliable software components,
- the ICES must provide the different actors (and particularly the pedagogues) with methodological assistance which will also aim at improving the efficiency of their cooperation. Features of Intelligent Tutoring Systems must therefore be integrated into the different tools provided by an ICES (specification tools, design tools, …). These functions will make use of the formalised methodology [Fraser et al. 94] on the one hand, and of information stored by the actors in the data repository on the other hand.

Several kinds of methodologies have been proposed but now most researchers agree that educational software is liable to incremental development [Boehm 88]: the different releases of a piece of educational software are evaluated through prototyping. Therefore, we must supply the pedagogues with a set of mechanisms which will allow them to express their pedagogical and didactic ideas and to check the consistency of their models (spiral life cycle):

- Simulation
- Pedagogical Specification
- Architectural Design
- Technical Implementation
- Pedagogical Implementation
- Educational Software
- Evaluation

Figure 1 : The life cycle model

The Rapid Prototyping Aspect

The simulation stage allows each pedagogue to assess his work by playing the role of the learner, using an educational software prototype. Therefore, the rapid production of an executable program is an important condition at this stage. Hence, an ICES must provide Rapid Applications Development mechanisms (RAD) and must enable the pedagogue to check his models against several points of view (that of the pedagogue who wants to transmit skills or notions, that of the learner, that of an instructor whose goal is to use the final piece of software with its students). These RAD mechanisms follow several principles:

- they rely on a software component library. Some of the components are purely pedagogical - like teaching strategies - while others are more media-orientated - like the interaction functions with the learner. This component library has to be consulted through a query language which manipulates pedagogical criteria.
- the pedagogues must be able to handle these components as executable entities. The values of the attributes of these components are exemplified during the prototype definition stage thanks to a "Visual Basic Editor"-like interface.
- the components are designed and stored with an object-oriented approach. This allows pedagogues to quickly create new components by specialising existing ones (addition of attributes or methods). Moreover this facilitates the definition of different points of view on the components.
We think that these general principles should be enhanced in any ICES tool so as to provide the users with methodological assistance, capabilities of reuse and facilities for evaluating their models. In the second part of this paper, we shall explain how we have applied these principles in order to develop an environment for educational software specification.

The Stage of Educational Specification

In order to tackle educational software specification, one must consider the interactions between the system and its environment (the knowledge to be taught, the characteristics of the students who will use the system, ...) [Bertrand 93]. So, at specification stage, one must first describe the objects in the educational system environment, and then define the role of the system in relation with these objects.

Any environment dedicated to educational software specification should be designed with the aim of reaching these goals. In practice, however, on top of designing educational software, we try to facilitate the teacher's work of preparing pedagogical sequences by defining the contribution of the computer. A minimum help should consist in recording the previously designed sequences and easing their retrieval by the teacher against pedagogical criteria. A more ambitious goal is to propose an environment that contributes to the definition of new pedagogical sequences:

a) From more or less abstract goals the teacher will have to refine and associate them with real situations he wants to propose to his class : exercises, problem-situations, ...
b) From a set of existing or re-used situations he will have to organise them so as to satisfy one or several goals officially assigned to the teachers.

The pedagogical environment we study in this paper should facilitate analysis by pedagogues whatever process they follow : top-down (a) or bottom-up (b). Teachers will be interested in such environment only if they can have three supplementary roles. Thanks to it, they should be able:

- to build up ideas that will be highlighted, refined and evaluated thanks to the environment, to modify and parameter any part of a course,
- estimate the educational capabilities of their specification by playing the role of the learner and then, of course, to criticise such specifications.

In the next paragraphs, we are going to show how our environment takes into account the ICES principles described in [ICES : PRINCIPLES AND GOALS]. We shall describe the method that we use for specifying a piece of educational software and the mechanisms we propose for prototyping the resulting specifications.

The Method

It is based on a model which organizes the pedagogue's activity into three stages [Nodenot 95] :

- a stage of definition of the aims of the curriculum. This stage is based on the fact that it is not suitable to provide the pedagogues with an environment whose capabilities are limited to the description of the only components that will be necessary when actually using the piece of educational software. Any specification environment should help the pedagogues define which components to be included in the curriculum. So the aim of this stage is to help the pedagogue describe the notions to be taught, the level of conceptualisation that the learner must reach and the higher-level objectives.
- a stage of syllabus design. This allows the pedagogues to refine these high level educational aims and go as far as clarifying the learner tasks.
- a stage of task description that will ultimately be proposed to the learner. This leads the pedagogues to formalize the Human-Computer Interface (HCI) specifications of the different tasks. Thus, they describe :
  - the command language that the learner can use : it is the set of elementary actions that the learner can do when a task is proposed to him/her,
  - the description language which is the set of symbols used by the computer to inform the learner about the task he/she has to achieve.

This specification method allows us to integrate the specification of the Human-Computer-Interface into a more global process. Hence, the specification of any multimedia animation should take into account both the HCI
ergonomics and the pedagogical aims.

Three kinds of objects can be handled at specification stage:
- **abstract objectives** which are educational aims that a pedagogue can check through the analysis of lower-level educational objectives - which are abstract objectives or concrete objectives. An example of the expression of an abstract objective would be "to master mental calculation".
- **concrete objectives** which are educational objectives that the pedagogue can check through the assessment of several tasks proposed to the learner (for example, the objective "to sort a collection of objects").
- **learner's tasks** which can consist of reading a document, solving an exercise, learning a lesson, ... During the specification stage, the only tasks that have to be described are high-level tasks (we are not interested at this stage in describing the fine-grained interactions between the machine and the learner but we focus on curriculum organisation, and this is the reason why no task refinement is allowed).

The components which are stored in the library can be one of these three types. Each object is formally described with "Spec" language [Berzins and Luqi 90]. This language, dedicated to formal specifications, promotes a formalism mixing abstract data types and first-order logic. This offers several advantages:

1) the interpretation of object specifications is non-ambiguous,
2) during the prototyping stage, we can make inferences on these objects to control the consistency of the descriptions made by the pedagogues.

From the different libraries, the pedagogue may use two mechanisms to describe the CAL objects of a particular piece of educational software: the instantiation mechanism and the specialisation mechanism. The specific constraints of such objects are expressed through "Spec" logic predicates.

Some assistance can be provided to the pedagogues from the formal specification of the method that we propose. This assistance uses Artificial Intelligence mechanisms based on inferences on the preconditions and post-conditions associated with each step of the specification process. The assistance can take different forms:

- it can, at least, provide guidelines and contextual on-line helps,
- it can provide capabilities of powerful Intelligent Tutoring Systems used for coaching the pedagogue in relation with the context of the task to be fulfilled.

In the next figure, we present the main components of the specification environment. We are now implementing these components [see CONCLUSION AND PERSPECTIVES].

![Figure 2: The components of the environment](image-url)

**The Prototyping Mechanisms**

The main aim of prototyping is to provide the end-users with a piece of software answering given specifications as early as possible. The users can then evaluate the appropriateness of the specifications and play an active part in the process of improving these specifications.

At specification stage, the prototype rather looks like a scale-model (or "maquette") [Crespel 91], that is a piece of software which has the features of the final product but whose evaluation does not integrate:
- features which are not very important to check the educational specifications,
- technical parameters depending on the characteristics of the target-machine.

The description formalism of these scale-models is based on the duality of objects and predicates (that the "Spec" language can tackle). The object-oriented approach allows us to handle abstract data types and to reuse these abstractions easily. Predicates are used to specify constraints on these abstractions.

The scale-model is built implicitly while the pedagogues are describing the specifications of a piece of educational software according to the method presented in [Nodenot 95]. Therefore, the environment accesses a toolbox containing objects that we can consider as instances of the different types of objects described in [The method]. Each object described in that toolbox relies on the "Model - Point of View - Controller" trilogy [Krief 92]:

```
MODEL
  Controller
    Msg
  Point of View 1
    ...
  Point of View n
```

Figure 3 : The "Model - Point of View - Controller" Trilogy

In this figure, the model specifies an abstract data type (structure + methods) which describes the educational component. Controllers represent different ways of chaining the different methods of the component. For each controller, points of view represent a particular interpretation of such chaining.

This trilogy is a key-factor for prototyping educational software:

- First, it allows us to provide each method of any educational component with a particular "interpretation" point of view which is used to run the associated method. According to the object type, this "interpretation" point of view will either be binary code (in particular for learners tasks), or a set of predicates to control if an educational objective has been satisfied.

- Secondly, it also allows us to manage several points of view for one particular pedagogical chaining (or controller). Thus, the points of view of a learner, of a pedagogue or an instructor can be implicitly taken into account. According to the type of user running the scale-model, specific information can be produced from these points of view: for one educational specification, we are then able to provide the pedagogue, at any time, with information showing him/her what the abstract or concrete objectives are that the system considers to have been satisfied. Without any modification to the scale-model, a person known as a learner by the system, will not be able to access such information.

The above prototyping mechanisms are completely integrated in the specification method. This allows us to limit some intrinsic disadvantages of prototyping with toolboxes [Krief 92]: in our context, pedagogues may not prototype everything at any time. They must follow the principles of the specification method whose formalisation is used as a coaching system.

Conclusion and Perspectives

In this paper, we have discussed the advantages of Integrated Courseware Engineering Systems for the design of high-quality educational software. These ICES are necessary:

- to integrate the technological improvements (such as the multimedia technology) into the whole development process,
- to aggregate the capabilities of the pedagogues with those of experts in these technological fields.

After presenting the principles of ICES, we have explained their features focusing on two points of view: the method and the prototyping mechanisms.

Then, we have presented how we deal with these features in the context of a particular stage of educational
software development: the specification stage. We have described the advantages of our method and shown that the pedagogical components stored in a toolbox are the starting point for any reuse; they are also the key-elements for a rapid prototyping step whose aims are to take into account different points of view for one educational specification.

At the moment, we are implementing this environment of specification using two types of tools. In order to implement the specification method, we use a Meta-CASE environment developed in an Artificial Intelligence laboratory in the University of Edinburgh: the HARDY tool [Smart 95]. This Meta-CASE environment allows us to associate a precise semantics with the activities of the pedagogue drawing diagrams to specify educational considerations. It allows us to generate formal descriptions in the form of predicates expressed in the CLIPS language [Giarratano 93]. In fact, CLIPS is an expert system generator which is able to handle rules dealing with classes and objects.

References


Abstract: The Educational Technology Laboratory at the Medical University of South Carolina (MUSC) has been involved in the development of two computer-based multimedia programs for middle school students. Both of the computer programs have a two-fold purpose: (1) to encourage middle school students to explore various environmental careers, and (2) to help students understand that high school is the place to start preparing for these careers by taking as many math and science courses as possible. Throughout the development process three main areas were targeted for formative evaluation: ease of use, how the programs performed, and accuracy, clarity, and depth of content. Over 650 middle school students participated in the evaluation of these programs and results indicate that students enjoyed using them and they met the objectives. Among the factors which contributed to the success of these two programs were the use of detailed design and evaluation plans, as well as clear and open communication between everyone involved.

For the past two years, the Educational Technology Laboratory at the Medical University of South Carolina (MUSC) has been involved in the development of two computer-based multimedia programs for middle school students. Both of the computer programs have a two-fold purpose: (1) to encourage middle school students to explore various environmental careers, and (2) to help students understand that high school is the place to start preparing for these careers by taking as many math and science courses as possible.

The first program developed, "Enviro Quest", is based on a super heroes theme. The character Kim Mystery explains how a knowledge of chemistry can help protect the earth from environmental pollution, and the careers highlighted include an air quality scientist, a wildlife biologist, an environmental engineer, and a toxicologist. The second program developed, "ROC-CD", focuses on the issues of recycling and conservation. A microbiologist, polymer chemist, mechanical engineer, and textile chemist, are the featured careers. Both "Enviro Quest" and "ROC-CD" have been distributed on CD-ROMs to all middle schools in the state of South Carolina.
The design team for each of these programs was composed of subject matter experts, an instructional designer, a programmer, and a graphic artist. Curriculum coordinators, administrators, teachers, and students from the public school system were also involved in the design, development, and evaluation of the programs. The development process for these two programs included the production of a detailed design plan composed of goals and objectives, flowcharts and storyboards, a formal evaluation plan, as well as the program's functional specifications.

Throughout the development process three main areas were targeted for formative evaluation:
- ease of use (user evaluation)
- how the programs performed (functional evaluation)
- accuracy, clarity, and depth of content (content evaluation)

The major purpose of user evaluation was determining whether or not the interfaces were consistent and easy to use. Functional evaluation consisted of determining whether or not the programs performed as specified. The evaluation of content ensured accuracy and determined whether or not students were able to meet the objectives.

The initial development of the first program entailed the design team spending four months producing two different interfaces with the same content. Subject matter experts reviewed the content in order to ensure that it was accurate and complete, as well as clear and concise.

Four schools were then selected as evaluation sites: one urban, one rural, and two suburban locations. For the first school evaluations, the programs were placed in one rural and one suburban school. While the programs were in these schools, the design team visited each school at least four times in order to observe users. Prior to conducting observations, the design team had developed a set of observation guidelines. For example:
- students would use the program with no comments from observers
- observers would interview the users following observations
- general questions would be avoided as much as possible (e.g., "Did you like it?")
- questions would be based on observations (i.e., "I noticed that you chose to leave a section before completing it. Do you remember why?"; "You chose ____ game first. What attracted you to that game?")
- factors such as ease of navigation, understanding directions, as well as facial expressions and body language to indicate boredom or loss of interest, were to be observed

While in the schools for observations, teachers and administrators gave their own impressions and observations of students' reactions to the programs. In addition to observations and interviews, each student who used the program, whether observed or not, completed a brief questionnaire regarding their preferred interface.

After compiling and analyzing the results of the observations, questionnaires, and interviews with students, teachers and administrators, the team decided to incorporate components of both interfaces into one program. Once the program was combined into a single interface, it became known as Enviro Quest.

Upon completion of these changes, "Enviro Quest" was placed on a CD-ROM, leading to a new round of functional evaluations conducted in the Educational Technology Laboratory. With the program now housed on a CD-ROM rather than the computer's hard drive, technical issues had to be addressed, such as video and animation performance, consistent sound levels, as well as the handling of the computer's memory.

"Enviro Quest" was then placed in one urban and one suburban school for further evaluation. A number of evaluation instruments were used: pre- and post-tests, observations, interviews, and written questionnaires. Students completed pre- and post-tests as one measure of the program's effectiveness. Also, each student who used the program completed a brief questionnaire regarding his or her likes and dislikes. Since students had limited amounts of time to use and evaluate the program, the team decided to make the questionnaire as brief as possible. The form asked for the students' age and grade, and contained general questions regarding whether or not they liked the program, and suggestions for changes. In addition, numerous observations and follow-up interviews were conducted with students, teachers, and administrators.

On the basis of the evaluation results compared with the original design plan, the team decided to make several changes: more instructional games added, some narration expanded to increase clarity of instruction, and several videos recompiled to improve playback speed from a CD-ROM. These changes did not impact
significantly on the original design, and the team agreed that they were crucial to the performance of the program.

In order to evaluate the latest changes, the program was placed in another school for a third evaluation by students. This evaluation followed the same procedures: observations, interviews, questionnaires, and pre- and post-tests. Following this final school evaluation, "Enviro Quest" was mastered onto a CD-ROM, duplicated, and distributed.

While "Enviro Quest" was being distributed, work began on the second program, "ROC-CD". Once again, the development and evaluation process was repeated: curriculum specialists, administrators, teachers, and students from the public schools worked with the design team during development and evaluation. Continuous user, functional, and content evaluations took place throughout the development process. Two schools were selected as evaluation sites; one urban and one suburban. Observations, interviews, questionnaires, and pre- and post-tests were once again the tools used to determine the program's effectiveness.

Throughout the formative evaluation process of both "Enviro Quest" and "ROC-CD", not every suggestion made or mistake observed resulted in a change to the specific program. If users were observed having problems in the same areas of a program, or the same suggestions made by various users, the design team discussed the potential problem areas, along with the pro's and con's of possible modifications. The team then compared these proposed modifications to the original design plan. Modifications that would have resulted in significant variation from this plan were not made. Since the program would have moved further away from its original goal, changes would have continued, and the project would have never reached completion.

In total, over 650 middle school students participated in the evaluation of "Enviro Quest" and "ROC-CD". Results indicate that, of the students who used Enviro Quest" and "ROC-CD":
- 93% met all of the objectives
- Prior to using the program, 8% could name and describe one environmental career; following use of the program, 80% could name and describe at least one environmental career
- Prior to using the program, 40% said they would like to learn more about environmental careers; following use of the program, 70% indicated that they would like to learn more about environmental careers
- 97% related that they enjoyed using the program

On the basis of on these statistics, both programs are successful: students enjoy using them and they are meeting the objectives. Many factors contributed to the success of these two programs:
- detailed design plans with a realistic timeline
- a design team that held organized and frequent meetings
- enthusiastic and cooperative educators and students
- clear and open communication maintained between everyone involved
- development and implementation of a well-designed evaluation plan

Future computer-based multimedia instructional programs developed by the Educational Technology Laboratory at the Medical University of South Carolina will require customized design and evaluation processes. However, basic features and issues will remain the same as those used throughout the development of "Enviro Quest" and "ROC-CD". For example:
- the involvement of as many people as possible, as soon as possible (users, subject matter experts, etc.)
- design plans, including goals, objectives, flowcharts and storyboards, if needed, along with the program's specifications, will provide an effective tool by which to guide the project
- the program's ease of use, functionality, and content will remain as three major areas of evaluation

During the presentation, portions of "Enviro Quest" and "ROC-CD" will be shown. A detailed description of the development and formative evaluation process used for these two programs will also be presented.

Access short videos on "Enviro Quest" and "ROC-CD" via the Web at http://www.gradstudies.musc.edu (select "Other Information on MUSC")
Courseware Market: Problems and Solutions

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Abstract: The paper discusses the problems and possible solutions related to the development of a world-wide accessible network of courseware repositories. We believe that the proposed solutions represent a fairly innovative approach for creating, maintaining, disseminating and most important of all reusing the courseware and efficient administration and maintenance of the large courseware repositories.

1. Introduction

The Institute for Information Processing and Computer Supported New Media (IICM) and Addison-Wesley Publishing Co. have decided to establish a courseware market based on conventional WWW compatible formats such as HTML Documents [Berk and Devlin 1991], still images, movies etc. amended by the HM-Card [Maurer and Scherbakov 1996, Maurer et.al 1995] interactive courseware modules. HM-Card is a hypermedia authoring system developed at IICM and currently distributed by Addison-Wesley. The courseware market comprises of material that can used free of charge and material which is distributed commercially by Addison-Wesley (with royalties to the authors). The paper mainly focuses on issues related to the establishment of large courseware repositories for world-wide dissemination of courseware material prepared with HM-Card. In particular, it describes the concrete theoretical and technical aspects and problems concerning the implementation of such a world-wide network of courseware repositories.

2. The Courseware Market: User’s Perspective

Courseware market or repository is a conventional web site which is accessible world-wide. The courseware repository is automated to maximum possible extent. Thus, the course instructional material is stored in a web server and have many clients accessing this material. In other words, the process of submitting a courseware, reusing the existing courseware (depending on whether it is free of charge or commercial); billing mechanism for the users, copyright protection, security etc. is automatically maintained by the courseware repository. The courseware repository provides automatic link maintenance mechanism, supports multi-level user accounts (for administrators, authors and users), security, copyright protection and so on. HM-Card modules constitute the main units of the courseware (see Fig.1). The contents of a particular HM-Card module can range from a linear-linked set of frames to complicated interactive courseware units with rich graphics, screen effects, animation, annotational facilities, answer-judging and response evaluation procedures. The courseware market is a pool of such HM-Card modules which refer to and are referred from conventional HTML documents. In other words, the users can navigate through the courseware repository using the conventional Web browsers like Netscape, Mosaic, Amadeus and so on. Additionally the Courseware Market provides an easy, integrated mechanism for different types of communication (see Fig.1) between students and the tutor (annotations, discussions, question-answer, etc.).
3. HM-Card

HM-Card [Maurer and Scherbak 1996, Maurer et. al 1995] is a set of tools that enables authors to build powerful interactive multimedia presentations and courseware. "Interactive" means that the system does not just allow the users to choose different paths from time to time, but that fairly complex system-user dialogues can be incorporated, e.g., for checking the level of understanding as required for training applications, hence the term "courseware". "Multimedia" [Hall 1995] means that HM-Card allows one to combine text, graphics, animation, raster images, audio and video clips. HM-Card has a built-in editor for text, graphics and animation and allows to import and integrate other media types (e.g., images and video clips) readily. Above all, HM-Card provides a new paradigm for "navigating" from one multimedia document to another, both with and without the use of so-called "hyperlinks". HM-Card includes powerful features to help ensure "link consistency" and provides a modular approach to the design of presentational packages and courseware that assures unprecedented ease in reusing and modifying existing modules. All tools necessary to create such applications are included in HM-Card. The preparation of material is done without having to program. Rather, authors simply select suitable media objects, define necessary parameters and place them on the screen - even computer animation and question-answer dialogues can be built this way. Material created can be structured so that it is easy to maintain, reuse and peruse modules.

HM-Card is thus suitable for both personal hypermedia authoring as well as professional multimedia publishing. HM-Card Material can be used "stand-alone" or via the Web.

4. Technical Problems
In the course of design of such a courseware repository we faced several technical problems. First of all the choice of the Web system was very crucial [Berk and Devlin 1991]. As first choice, the first generation Web servers like WWW, Gopher were considered. These servers provide efficient mechanisms for storing and transporting data. The HTML format is used for representing information. Links can be embedded into the HTML documents in the form of so-called URLs (Universal Resource Locators) which point to any kind of data [Berk and Devlin 1991]. When such a link is followed, the browser downloads the corresponding data and executes the associated viewer. However, this is not adequate for the following reasons:

- Link maintainance of large courseware databases becomes rather tedious and cumbersome;
- It is impossible to structurally, contextually organise the courseware material;
- The links among the courseware material are devoid semantics and context, which eventually result in a sphagetti-like information structure;
- It is not possible establish links between among courseware materials as such. In other words, the author of once courseware cannot establish a link from his/her part to another courseware material.

The second-generation web servers like Hyper-G [Kappe et. al. 1993] considerably alleviate the above mentioned problems. The courseware material can be structurally organised using so-called global links which reside in a special link database, or in other words, simplifies the administrators of large courseware repositories to categorise the material. Hyper-G provides various kinds of efficient data retrieval mechanisms which is of great interest from the user point of view. The courseware material stored in Hyper-G can be referenced from text (HTML, HTF format), pictures, 3D-images and so on. Hyper-G provides multi-level access control and efficient security mechanisms.

In this paper we contend that "simple links" to the courseware material does not suffice the demands of creating large repositories of courseware. For instance, if a courseware material refers to other courseware materials in the repository, then it is quite difficult to implement such links without additional workarounds. We present a so-called Document linking and Embedding mechanism on the basis of HM-Data model [Maurer et al. 1994a, Maurer et al. 1994b] which provides seamless interconnection among various courseware materials within the repository and most important of all is capable of seamless interoperability with the Web servers.

5. Embedding Courseware Modules into the Web

It should be especially noted that the HM-Card supports a new type of linking, conceptually somewhere between the local (URL) and global link models [Maurer et al. 1994a, Maurer et al. 1994b]. In HM-Card, links neither belong to individual nodes, nor are they globally addressable objects, but they are encapsulated within hypermedia containers called Structured Collections [Maurer et al. 1994a, Maurer et al. 1994b].

By definition, links cannot point outside a structured collection, but only between its members; hence structured collections represent well-defined chunks of information, which may be re-used in various contexts without concern for superfluous hyperlinks. The model compensates for the restriction of links to local contexts by introducing memberwise inclusion of hypermedia chunks and special browsing operations which can Open a structured collection for browsing and Close it.

HM-Card has an export facility capable of generating a structured interchange format (SIF), which can be stored on a Web server, and which can be retrieved and interpreted by a standard client (for example Mosaic, Amadeus or Netscape) using a stand-alone HM-Card Viewer as a so-called Helper Application (see Fig. 1).

At the global level of data representation (i.e. on the Web), structured collections in the SIF format can be treated exactly in the same way as conventional documents. They are uploaded, provided with URLs and referred to from within other documents (see Fig. 2). The only difference is that an structured collection encapsulates a particular navigational structure which is not supported at the global level and which is activated via the additional "Open" operation.

The "Open" operation results in activating the HM-Card viewer and creating a new window where the structured collection can be browsed independently using the internal (i.e. encapsulated) link structure (see Fig. 1 and Fig 2).

Note that a structured collection may also include other structured collections as so-called members. A typical situation would be when a particular course (i.e. a structured collection) consists of chapters (i.e. structured collections) and the chapters have cross-references.

When exporting a structured collection to SIF, member structured collections can be treated in two different ways: Local and Remote (see Fig. 2).

Local means that the member collection is embedded directly into the SIF file. In this case, when the SIF file has been downloaded, the member collection can be "opened" by the HM-Card Viewer without any additional communication with the Web.
Remote means that the member collection is embedded with information about its actual content (such information is called a Label [Maurer et al. 1994a, Maurer et al. 1994b] in HM-Card terminology) together with a placeholder for a corresponding URL. It is assumed that the member collection has been (or will be) exported into a separate SIF file. The actual URL depends on where the corresponding member SIF file is (or will be) located on the server. In this case, the "open" operations initiate the downloading of further SIF documents. In the current version of HM-Card an actual URL is entered manually into the SIF files, but it will be generated automatically in future versions of HM-Card that allow Web access from within HM-Card. Such optional dynamic access to a global hypermedia database allows automatic reuse of all hypermedia resources available at the current moment in time.

Any links encapsulated within exported structured collections are, of course, also encoded in the SIF file. For instance, a particular chapter of a course can be exported and, thus, can be made available for re-use, or it can be defined as just part of a number of other structured collections created by one team. Hence, authors can decide upon the desired level of reusability of their courseware for themselves. If only the course had been exported and all chapters had been embedded into the SIF document locally, only this course can be reused and referred to as a whole. The above possibilities create a new technological basis for embedding courseware material into the Web.

First, actual integration of material from other systems or other formats becomes feasible providing that such materials can be put on Web servers and stand-alone viewers which can be used as Helper applications exist. This makes it possible to reuse course material already prepared or to combine material from different sources of courseware. A particular HM-Card database is a combination of independently created modules. The modularity provides a necessary basis for structuring the process of courseware design and flexible re-use of existing courseware. Thus, complex data objects are re-used rather than referred to (see Fig. 2 where remote structured collections are incorporated into navigable structures of other collections). The distinction is apparent within the interface metaphor: a reference implies jumping to another location (with only one way back), re use implies embedding the external object into the current context (with the possibility of later switching to another of the contexts within which the object is used). In programming language terminology, links would correspond to goto statements and embedding to procedure calls.

A distributed hypermedia system provides access to a background repository of educational information (i.e., to a huge number of reusable and fully-compatible hypermedia modules prepared in the form of courseware fragments) independently of who the author is and where the material is stored. Therefore, multi-user development of hypermedia databases is greatly facilitated.

If, upon reading this, you have the feeling that this is science fiction, take a look at http://www.iicm.tu-graz.ac.at/Ccourseware

Further advantages are obvious when authoring and presentation systems can be operating stand-alone without the need to access to remote distributed courseware repositories.

Suppose we need to support collaborative authoring by several authors who work together on a courseware project. Structured collections may well be created by different authors working with different databases. They can be easily combined into one database which is put on a floppy or CD-ROM for further distribution. Note that structured collections can later be exported from the database to make the same materials suitable for the Web or for re-use of particular parts in other projects.
For example, the courses "Introduction to Databases and Relational Data Model" and "Object-Oriented Databases" are available in two different forms: you can FTP the whole courses from:
ftp://iicm.tu-graz.ac.at/pub/hmcard/rcourse.zip
ftp://iicm.tu-graz.ac.at/pub/hmcard/oocourse.zip
or you can browse it on-line in the "courseware market":
http://info.iicm.tu-graz.ac.at/Courseware

Teachers at universities are creative people who have their own ideas, points of view and methodological approaches which they want to incorporate into educational materials. This is also a reason why courseware modules are often not used by people other than the original authors. Thus, the mere copying of previously prepared courseware into a hypermedia system is not sufficient. Teachers must have the chance to access existing source material and courseware modules, and rearrange them for their particular needs. This idea of personal authoring includes the possibility for teachers to take complete documents or only parts from other authors' work, as required. However, it needs to be guaranteed that the original authors' work is protected, i.e., the intentions of the author of a particular course are not violated when parts of the course are used by another author.

In HM-Card, each author can concentrate on the creation of a number of self-contained collections, safe in the knowledge that they will not conflict with other authors working on separate collections, and that the finished collection will be re-usable in any number of different contexts. Note that modification of a particular collection does not affect other. Hence, an original authors' composition of a collection is protected.

6. Contributions to the Courseware Market

To contribute an HM-Card module, submit your HM-Card courseware together with a short HTML description to ftp://ihm-iicm.tu-graz.ac.at/pub/marketincoming.

It will be briefly checked for technical correctness and to ascertain that the contents do not violate Austrian law. After this check, the course will be added to the electronic courseware market. It will then be available worldwide and can be used by anyone for non-commercial purposes as long as you are clearly quoted as the author and the material is used unabridged and unchanged!

Contributed HM-Card courses (i.e. groups of lessons with an introductory lesson and documentation) are treated similarly but have to conform to what is outlined in Section 6 of [Maurer and Scherbakov 1996]. If you wish, HM-Card courses will be considered for commercial distribution by Addison-Wesley. In this case, only the (partial) documentation and some material (typically introductory Lesson 0) will be available electronically on the Web. The complete courseware package will be made available for a fee from Addison-Wesley on floppies or on CD-ROMs. You will, of course, be able to negotiate royalties with Addison-Wesley. IICM and Addison-Wesley reserve the right not to incorporate any courseware into the courseware market or delete existing material without giving any reasons.

Note that the courseware market is considered as a service for HM-Card authors and users. Please make use of this possibility but note that developments may necessitate changes concerning courseware market policy in the future.

7. References


HM-Card: A New Approach to Courseware Production

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Abstract: In this paper we analyze current trends in courseware development, focusing on the fact that most authoring systems today require too much of an investment of effort to produce multimedia courseware. We offer a new authoring paradigm which makes production of courseware easier and more productive. We also describe a particular system, called HM-Card, which supports this paradigm. This system, as well as help files and a number of courseware examples are available via ftp: ftp://iicm.tu-graz.ac.at/pub/hmcard15

1. Introduction

It is clear that interactive multimedia courseware would be very useful in education [Vaughan 1994]. By interactive, we mean multimedia where students can alter the flow of execution with their own input and thus get individualized feedback. This would be far more instructive than a simple linear presentation, which would take the same course regardless of the student's level of ability. However, as useful as interactive multimedia would be, the goal of using it in the classroom has not been fulfilled to nearly the extent it could be. While non-interactive multimedia documents, such as a text with pictures, can easily be produced by anyone using the software tools currently available, instructors would have to make a significant investment of time to learn to make satisfactory interactive multimedia courseware. The immediate goal then, if we are ever to realize the ultimate goal of using interactive multimedia in education to its fullest extent, is to make it realistic for instructors to prepare useful interactive courseware even if they have no prior knowledge of programming [Goodman 1990].

What is needed is a new authoring paradigm, one which allows authoring to be done with minimal training, and which allows the flexible re-use of previously prepared materials to produce courseware which can be aimed at different groups with different levels of ability. In this context we offer one possible authoring paradigm which might solve the currently existing problems with the difficulties of authoring interactive multimedia courseware. This paradigm is called the HM-Data Model [Maurer et al. 1994b].

Normally, authoring packages require programming to provide a reasonable level of interactivity, thus making the production of multimedia courseware feasible only for professional programmers. The scripting paradigm (see, for example, [Sims 1994] and [Hall 1995] ), is one in which a programming language is used to specify multimedia elements by filename. Similarly, in the well-known icon paradigm, the flow of execution is specified in a form very close to ordinary "if . . then" statements. In both cases, in-program editing of multimedia elements and on-line modifications of courseware are rather restricted.

Basically, the HM-Data Model provides a new paradigm to specify interactions: it is a non-programming approach, which makes the creation of interactive multimedia courseware easy and productive for educators who don't happen to be skilled in programming [Maurer and Scherbakov 1996].
The model operates on two kinds of entities: multimedia pages and computer-navigable S-collections. Multimedia pages are the ultimate basis upon which courseware modules are built. The HM-Card editor provides a way to quickly produce customized pages using a wide range of types of multimedia object. Text can either be entered directly or can be imported from an external application. Images in different formats can be imported using different techniques. Drawings using lines, curves and simple shapes can be made with its vector graphics facilities. A number of objects on an existing page can be saved as a group and then reused in other pages with the click of a button. A beep or a flash can be incorporated into a page as a warning or to attract the user's attention. Any visible object or group of objects can be animated. The page editing in HM-Card follows the WYSIWYG metaphor. Of course such multimedia pages are rather conventional objects which can be found in many different authoring environments.

A really innovative feature of the HM-Data Model is that courseware content and structure are treated separately [Maurer et al. 1995] meaning that previously prepared courseware fragments can be re-used in newly created courseware modules. Simply speaking, human-machine interaction can be seen as a metaphorization of all actions available to a user in a particular current state of courseware execution and the options for changing to another state when an action has been carried out. This situation can be modeled as a large number of multimedia nodes which represent states of the courseware, interrelated by means of computer-navigable links representing possible changes of state [Berk and Devlin 1991]. So-called anchors visualize links in a particular form suitable for human-machine communication (for example push-buttons, check boxes, "hot" words, clickable areas, input fields and so on). The remainder of this paper is dedicated to describing the HM authoring paradigm.

2. The HM-Data Model

With the HM-Data Model, information is organized into units called structured collections, S-collections or simply collections. A collection can be seen as a closed environment which contains a structure of navigable links between the nodes (which will henceforth be called members) contained in it. There are several predefined types of collection. An envelope has links back and forth between every combination of two members in the collection. A folder joins members into a list, with links to next and previous members. In a menu, one specific member (called the collection head) has links to and from each of the other members. Lastly, with freelinks, users can link the collection's members in any manner they wish.

Not only do menus have collection heads, but so does every other type of collection. The collection head is a member designated to be seen first when the user starts browsing a collection. This, as we shall see, is important with respect to the navigational mechanism in this paradigm. Also, a collection can have associated with it a label, a page which describes the content of that collection. These collections, which can be seen as separate containers in which link following can only be done between members of that container, can also themselves be members of other collections and can have either other collections, simple pages or both as members.

The nesting of collections can be arbitrarily deep. Recursive membership is possible, i.e. a collection can have itself as a member or contain a collection which has it as a member. Also, each collection is required to have a unique name in a given HM-Card data base.
Now that we have discussed the basics about structure in the HM-Data Model, it is time to talk about its navigational operations. There are three important operations, which are called OPEN, CLOSE and ACCESS. The OPEN operation lets users do exactly that— they open a collection with it. As mentioned earlier, each collection has a certain internal structure. When one is opened, the environment the user is in is switched from one collection to another. The internal structure of the opened collection is there for the user to browse, so until another collection is opened, the user can only navigate within this collection, always starting with the head of that collection. The CLOSE operation is the opposite of OPEN. It causes the user to leave the browsing environment of one collection and go back to the context of the collection in which it is contained. The third operation, ACCESS, is what the user uses to navigate between the members within a collection. It is similar to following a hyperlink, except that when users access a member of a collection, that member could be a simple page or it could be another collection, and in this case, what they see first is its label, which gives them information about what is inside so they can decide whether to open it and explore its internal structure or access the next member. An important advantage of this data model when used for the preparation of educational software is that it allows flexible re-use of material. To be more specific, each collection which is prepared, whether it is simple or contains many levels of nested collections, can be used in as many other collections as the courseware author wishes. This powerful feature means that an author can treat collections which have already been created as modules which can be inserted as appropriate into new presentations. This can be done easily, and as often as the author likes. There is no limit on how often a collection can be re-used, nor is there any need for the author to know anything about the underlying mechanism that makes this possible. Programming approaches to interactive multimedia authoring cannot offer this kind of flexibility.
3. Creating Collections with HM-Card

This is to give an idea of how the HM authoring paradigm contrasts with forms of authoring which require programming (see also [Maurer and Scherbakov 1996] and [Maurer et al. 1995]).

Basic steps in creating a collection:
1. The author clicks on the "new collection" button
2. The author specifies the type of collection (menu, freelinks, etc.)
3. The author chooses a collection from the set of existing collections to be inserted as the head of this collection. This is done by looking through a list of the unique names of these collections and clicking on them.
4. The author chooses a page as label for this collection.
5. The author inserts new members, either pages or collections, into the new collection with the INSERT_MEMBER operation. The members are linked automatically according to the chosen structure (unless its type is freelinks, in which case the author has to connect the members with the INSERT_LINK and REMOVE_LINK operations). As can be seen from these steps, this method is not difficult to learn and is at a much higher level of abstraction than programming methods. Thus the courseware author is not distracted by implementation details and can concentrate on the goal of making interactive multimedia courseware.

4. Different Views for Different Groups

Now that the basics of the structure and navigational operations have been explained, another advantage of the HM-Data Model can be discussed, namely the ability to use it to easily produce interactive presentations aimed at students of different levels using, at least partially, the same material. The important point here is that links in an HM-Card data base are context dependent. Links are never embedded in content, but exist in the context of a collection. Links are not global to an entire data base, but are followable according to which collection the user is in at a specific time. When the user is in a certain collection and he accesses (follows a link to) a certain member, it doesn't matter how that particular member is linked to other members of other collections, the only links that are visible to the user when he is navigating in a collection are the links which specifically belong to that collection. Thus different collections can be used to present the same information in different ways for students who have different levels of ability or different interests. This and the fact that a collection can be used as often as desired make it possible to make new presentations with existing material with minimal investment of time. This concept may be slightly difficult to imagine at first because in most multimedia paradigms, the links between objects are global, that is, they can be seen at all times. Thus the attempt to use the same objects to produce two different views of the same material with these paradigms would be pointless, since the links present in those objects would ultimately lead users to objects they were not originally intended to see. With the HM-Data Model, the user has no chance of accidentally following a stray link and of course cannot "get lost in hyperspace."
5. An Example

Here is a simple example to help make clear how an HM-Card database can be structured, and how this structure can be advantageous when preparing courseware. Say, for example, an instructor would like to prepare two different collections about birds (see Fig. 3). For one group, she would like to give a general overview of birds and for the other, she would like to present a more specialized view, focused on flightless birds. She prepares several collections, with the names ROBIN, PENGUIN, CARDINAL, OSTRICH and KIWI. These collections may contain information about the area of the world where this particular bird lives, the bird's appearance, what it eats, etc. It doesn't matter what the content or internal structure is like, once a collection about a particular type of bird is prepared, it can be seen as an individual unit of information which can be re-used in one or more other collections.

![Figure 3: A sample HM-Card Database](image)

The instructor can now use these collections in her courseware for the two different groups. She creates two collections, named BIRDS_GENERAL, of type folder, and BIRDS_FLIGHTLESS, of type menu. In BIRDS_GENERAL, she chooses the collection ROBIN to be the collection head and then inserts PENGUIN and CARDINAL. In BIRDS_FLIGHTLESS, she prepares a list of birds to be the head and inserts OSTRICH, PENGUIN and KIWI. Now she has created two different collections which re-use some of the same material. However, she also wants to make it possible for the group specializing in flightless birds to have an opportunity to go back and review some facts about birds in general. Thus she simply inserts BIRDS_GENERAL into BIRDS_FLIGHTLESS. Also, she would like the other group to be able to move on to more specialized information about flightless birds once they have some general knowledge about birds and thus she inserts BIRDS_FLIGHTLESS into BIRDS_GENERAL. Now the groups have two different views of the same material using two different styles of interaction. Members of one group can only turn pages (folder) and members of the other can look at a list and freely choose which type of bird they would like to learn more about. As can be seen from this example, the HM-Card authoring paradigm allows the re-use of collections in the context of different collections which are aimed at groups with different interests. It also allows recursive membership, as in this case where BIRDS_GENERAL contains BIRDS_FLIGHTLESS, which again contains BIRDS_GENERAL, thus easily handling the instructor's wish to give each group a particular lesson, as well as to permit them to eventually refer to further information about the same topic.

6. Conclusion

As can be seen from its description, the HM authoring paradigm is simple to learn and at a far higher level of abstraction than programming-based authoring paradigms. It allows flexible re-use of previously created
materials in new presentations, thus allowing courseware authors to produce useful interactive multimedia with a minimal investment of time. The fact that links are local to a collection rather than global allows the same material to be seen in different contexts. Because HM-Card is so easy to use and so powerful, we conclude that it has the potential to remove the existing obstacles to the effective use of interactive multimedia courseware in the classroom.

7. References


Creating A Multimedia Interface To Teach Inexperienced Circuit Board Assembly Line Operators How To Correctly Assemble Circuit Boards.

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Abstract: Interfaces combining natural language, speech and graphics take advantage of both the individual strengths of each communication mode and the fact that these modes can be employed in parallel. It is important to co-ordinate these media so that they improve communication capabilities. A key concern is the selection and integration of multimedia output. The objective of this paper is to describe the design of a multimedia interface which incorporates co-ordinated graphics, text, verbal and audio input and composes multimedia output for use by both technical users and operators within Northern Telecom.

1. Introduction.

MICASSEM (Multimedia Interface for Circuit board ASSEMbly) is a multimedia extension to an existing application that incorporates voice, graphics and text in such a way that it adds to the user friendliness of the package, and enables production line operators and engineers to use the package both efficiently and comfortably. This interface enables operators to gain instructions on how to assemble circuit boards on the Northern Telecom shop floor, as well as allowing engineers to change the content of the circuit board layout diagrams. The objective is to simplify the interaction of the shop-floor operators by developing an interface that accepts co-ordinated graphic/text/verbal/audio(sound) input and composes multimedia output which best conveys the information to the operator or engineer.

2. MICASSEM’s environment.

This interface is currently undergoing development for the Northern Telecom plant, which is based at Monkstown, outside Belfast, N.Ireland. Within this plant the production process has been largely automated, but there is a stage of manual assembly which is completed by operators on the shop floor. Manual assembly is supported by a set of manual assembly sheets which are displayed on a terminal in front of the operator and which do not make allowances for different skill levels and different types of users. Thus problems such as confusion arise for inexperienced operators which MICASSEM overcomes by providing easy to follow screens and allowing the user to choose which type of interaction they prefer.

For example, a user can choose to interact by pointing, using written or spoken natural language, or a combination of some or all these interaction types. Also with the manual system currently in use at Northern Telecom it is impossible for the engineers to take a circuit layout diagram and alter it so that each operator or engineer automatically receives an updated copy of the circuit board layout diagram as well as the new assembly instructions, and for the new details to be automatically added to the database. MICASSEM overcomes these problems and ensures that each operator has an on-line copy of the current circuit board diagram layout as opposed to a paper copy which may be out of date.

3. Description of MICASSEM.

MICASSEM aims to enhance the manual assembly process provided by Northern Telecom’s ASSET system [3]. MICASSEM’s interface enhances the ASSET software by enabling the assembly sheets to be displayed automatically on a terminal by either pressing the keyboard keys or speaking into a microphone. In addition voice, graphics and text are to be incorporated into the output of the system. In order to achieve this a software development environment known as Hipworks (developed by Integral...
Solutions Ltd.) is used which incorporates hypertext, multimedia and expert system facilities, with POP-11 being used as the underlying development language. Figure 1 illustrates the ASSET system’s components and illustrates how the Hipworks development environment enhances the output from the ASSET system by allowing different media combinations for input and output.

Figure 1 High-Level MICASSEM Architecture

4. Facilities of MICASSEM.

The interface helps to overcome difficulties such as ambiguities and misconceptions encountered on the shop floor by combining media to accomplish certain tasks, for example, illustrating assembly instructions on a circuit board screen layout by pointing at them with the mouse, then eliciting a textual explanation along with a voice output. The selection of output media will be based on the technical aspects of the task and context and (ii) the user’s preferences and (iii) the type of user.

The approach being taken is to allow the system to be as human-like as possible by allowing input from different sensory devices (eyes, hands, ears). The system includes language parsing to cater for the compound input streams, a database, and a focus base to permit a basis for decision making. Due to the use of different media the interface offers the user the option of choosing which medium or combination of mediums that they feel happiest with as their means of interacting with the system. The system also automatically composes and generates relevant output to the user in co-ordinated multi-media using both canned text and frames as generation techniques. Also the system judges the relevance of information with respect to the current focus and the user’s task.

5. System Components

The components for the system are shown below in Figure 2. The operator can request a display of the assembly sheet using speech, mouse, or keyboard input. The operator may then query the assembly sheet by clicking on the appropriate places (i.e. chips or buttons). This information can be obtained in the form of speech or natural language (depending upon whichever he/she has specified). Once the operator has finished the task involving the assembly sheet he/she can proceed by either entering a natural language word such as 'Continue' or by clicking on a 'Continue' option, or by entering a speech input such as 'Next'. The input component contains an auditory input device, a keyboard and a mouse. The Input Coordinator accepts input from the three input devices and it preserves the order in which the inputs occurred. The Parser is based on pattern matching and is used so that a wide variety of sentences may be accepted as long as they contain certain valid keywords. This caters for the acceptance of the input stream produced by the input coordinator and produces an interpretation of this stream. The Execute Task component carries out the appropriate action. This could be for example to obtain more information on a certain chip. The Output Unit analyses the results of the Execute Task component and decides how these results should be communicated to the user. The Output Unit then produces visual/auditory output. This module is responsible for ensuring that the corresponding output is carried out in the correct sequence. The Output Component contains both a visual component (text and graphics output) and an auditory component (speech output).
The system also uses Knowledge Sources [Mc Caffery, McTear: 95] for understanding the input to the system and for generating the output from the system.

These knowledge sources used are:

(1) a lexicon which is collection of all morphemes, tokens and signals that carry meaning in a given language.
(2) a grammar that defines how the components of the lexicon can combine to form legal composite language structures.
(3) a user model that takes into consideration the user’s level of expertise in performing the current task as well as preferences concerning the mode of communication.
(4) a help module ensuring that the user gets the appropriate help (at the right technical level) and not pages of irrelevant information.
(5) a focus model that is used to avoid ambiguous reference by highlighting the object most relevant to the user’s task.
(6) a database of shop-aids components which includes all the information concerning a particular component that may be assembled on a circuit board on the shop floor, this may include both operator information and technical information.


The Output Unit is responsible for the message content and mode selection. The chief question is how to divide a communicative goal into subgoals which can be satisfied by specific mode generators so that they complement each other. This is resolved in this project by the use of the Output Unit. Routines have been designed which decide on the appropriate output for a particular circumstance and this is based on a strategy proposed by Andre and Rist [Andre, Rist: 90], and the methods of Moore and Swartout [Moore, Swartout: 89], for the operationalisation of the RST theory for the planning of text.

Within the system the user can specify if they want to have speech, speech and text, text only, speech and graphics, speech and graphics and text etc.- basically any combination of these three modes, provided that it is viable for the type of query and the category of user that is involved. These values may be set by the user or may be set automatically depending on the type of user. For example, a default voice output is not provided for expert users, as they often find this annoying. However they may turn the voice output back on if they wish, by clicking on a voice icon.

The rule governing the allocation of media is
Display (Type of Instruction,Content,mode )

Examples of this would be:
Display(Speech,<Recorded speech filename>,true);
Display(Text,”text-message”,true);
Display ( Graphics pointer, ( co-ordinates, message ), false );

If the value of mode is false, then the Display task is not performed. If the user clicks on a component on the screen, the focus model is then set to the value of that component and the co-ordinates of the <Graphics pointer> are set to point to this component. By clicking on a component this also sets the value of the <mode> parameter to “true”.

The output commands would then become equal:

Display(Speech,<Recorded speech filename>, true).
Display(Text, “text-message”, true).
Display ( Graphics pointer, ( co-ordinates, message ), true );

If the user then clicks on an instruction button a PERFORM command is activated in conjunction with the interaction modes to produce the desired output.

The structure of the PERFORM command is:

PERFORM( lookup(database, <focus value>, <instructions> ).

This command searches the database for the assembly instructions of the component whose value is equal to that of the current <focus value> parameter of the command.

For example, if chip “TMS4164” is the component in focus this yields the command:

PERFORM( lookup(database, TMS4164, assembly instructions).)

The PERFORM function is in effect the <Content> section of the Display function, and therefore for this example the Display function would be:

Display(Results,PERFORM(lookup(database,TMS4164,assembly instructions ), mode).)

Here the value of mode is decided by the user’s preferences for a particular type of interaction. Thus the system displays the assembly instructions of component “TMS4164” in whatever mode or modes the user desires.

The particular media chosen for output allocation is also based on rules by Arens, Hovy and Vossers [Arens, Hovy, Vossers: 93]. These rules are illustrated in Mc Caffery and McTear [Mc Caffery, McTear: 95] and are currently executed externally to the system as a method of deciding which media should be chosen for a particular instance, however it is planned to develop the system such that these rules may be used within the system to decide what medium should be used for a particular output.

As well as through the use of the media allocation rules, the selection of a particular medium may also be determined either in terms of the task involved or in terms of a preferred user style of communication. An obvious example of task-related selection is where speech is chosen as the input medium if the operator is working with a circuit board and keyboard input is inconvenient. Speech is also particularly useful when presenting messages to attract the operators attention, and other information when the operator is unable to attend to the screen. Graphics are a useful medium for showing the circuit board chip and highlighting areas of the circuit board, while natural language is appropriate for textual messages, as well as an accompaniment to graphical displays. The integration of these different modes of interaction brings several advantages. Potential ambiguities and misconceptions may be eliminated if two media are used together, for example, having a picture combined with a textual explanation.

7. The provision of system adaptivity through user modelling.

The system is also designed so the that the dialogue matches the user’s preferences and level of technical expertise. This is achieved through a user model which contains information about users that is relevant to the dialogue behaviour of the system. More specifically, user modelling involves acquiring and storing
information about individual users or classes of users and then utilizing this information to guide the behaviour of the system (cf. [Kobsa, Wahlster: 89] and [McTear: 93]). At present the acquisition of user information is achieved simply by asking users to select their own classification. This involves selecting between different levels of technical expertise (novice, intermediate, or expert). Similar classifications of user type and level have been used widely (see, for example, [Chin: 89] and [Murphy, McTear: 93]. It is recognised that this basic method of user classification is not without its problems. A false classification may arise if users over-estimate or under-estimate their abilities. Furthermore, users may be an expert in some parts of the system, but a complete novice in other areas. One possible solution would be to provide a more dynamic user model which could be amended according to inferences based on the ongoing dialogue, such as the time the user takes to respond to a prompt, the type of error messages displayed, or the detail of help provided (see, for example [Murphy, McTear: 93]).

The user model is used to provide adaptation to input mode as well as output content and mode. As far as input mode is concerned, experts would be allowed the use of features such as abbreviations, and typing and answering ahead, while novice users would be provided with default answers and multi-level help. The use of synonyms would enable individual users to choose the most natural identifiers, while partial matching would reduce input errors for all types of user. The main benefit of the user model for the present system lies with the output as it is possible to provide a personalised interface for each user. Users are further differentiated according to their level of expertise, which determines the nature of the information provided. Novice users receive detailed information, intermediate users receive brief descriptions, and expert users receive brief descriptions with more technical details included. This classification is rudimentary at present but is to be validated empirically. One potential enhancement would be to differentiate the information along the lines suggested by Paris [Paris 88] i.e. process-oriented information for novices and structure-oriented information for more advanced users.

8. Related Work

An example of a similar system that combines natural language and graphics is WIP: Knowledge-based Presentation of Information [Wahlster, Andre, Bandyopadhyay, Graf, Rist: 91]. WIP generates a variety of multimodal documents from an input consisting of a formal description of the communicative intent of a planned presentation. Other examples of multimodal dialogue systems include: ALFresco [Stock: 91], which displays short video sequences about Italian frescoes on a touchscreen and answers questions about details of the videos and CUBRICON [Neal, Shapiro: 91] which is an intelligent interface to a system for mission planning and situation assessment in a tactical air control domain. Thus it can be seen that intelligent multimedia is a research domain full of unresolved issues of considerable complexity, including the technical aspects of combining different media, questions of system architecture, and the ergonomics of software design.

9. Conclusion: Future areas of research.

MICASSEM caters for the requirements of both operators and engineers by permitting:

- engineers to access circuit board layout diagrams that have been previously created, and enables the engineers to change the component organisation within the circuit board layout diagram, as well as changing the actual components used within the circuit board layout diagram.
- operators to access information concerning how a particular circuit board should be assembled.

Currently all the components mentioned in the paper are in place, however at present the ‘intelligence’ of the system resides mainly in the use of a user model to provide an adaptive interface for the user in terms of levels of system output, as well as input and output modes. Future work is likely to focus on providing an intelligent method for the selection and coordination of media, based both on the user's current task and the information in the user model. Some empirical investigations will also be required to validate the usability of the system for the relevant groups of users and to determine user preferences for different media as well as the effectiveness of the interface.

10. References.


A Flexible Multimedia Tutoring System for Medicine

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Abstract: Over a period of seven years, work has been in progress at Sheffield on the development of Tutoring Systems that present simulated case studies in medicine. The SIMPLE LINCTUS System was in routine use in the Department of General Practice in the Medical School for a period of four years. Work has been completed on a new Tutor that will be part of the Wellcome Trust's Electronic Museum of Tropical Medicine. This Tutor has access to a multimedia database of resources (text and pictures) and has been designed together with a range of authoring tools that permit the Tutor to be tailored to different medical environments. This paper briefly describes SIMPLE LINCTUS and then describes the authoring facilities that have been developed in conjunction with the new Tutor.

The traditional approach to implementing an intelligent tutor in medicine has been to base it on an existing expert system that can diagnose and treat patients in the domain of interest, for example MYCIN [Shortliffe 1976] and NEOMYCIN [Clancey & Letsinger 1984]. The tutoring system is then built using the expert system as the source of knowledge to be communicated to the student, for example GUIDON [Clancey 1987a] and GUIDON-2 [Clancey 1987b]. We at Sheffield have, from the outset, adopted a rather different approach. Data for each disease is stored separately and the Tutor uses this data to automatically generate case studies for presentation to students. The tutoring process is guided by the notion of the 'differential diagnosis' - the list of diseases that could account for the symptoms and clinical signs that have been elicited so far during a consultation. The differential diagnosis is constructed in the Tutor by cross referencing the entries in the disease Database or 'knowledge base'. This approach results in a very simple modular representation of the disease data and lends itself to easy modification and expansion of the data using a Database Editor.

1. SIMPLE LINCTUS and the Clinical Challenge System

SIMPLE LINCTUS [Mansour et al. 1990], [Poyser et al. 1990] is a Tutoring System, written in Prolog, for giving medical students experience in the Primary Care of patients. The system simulates the patient-doctor interaction and criticises the student's performance in managing the patient when appropriate. SIMPLE LINCTUS was in regular use in the Department of General Practice in the University of Sheffield for four years. The user interface in SIMPLE LINCTUS was entirely text based and this limitation was a function of the cost of the technology available at the start of that project.

SIMPLE LINCTUS has been subsequently developed and rewritten as the Clinical Challenge System, a component of the Wellcome Trust's computerised Museum of Tropical Medicine. The Challenge System is a Tutoring system intended to present diagnostic challenges to doctors training in tropical medicine. The computerised Museum to which the Challenge System has access contains a range of hypermedia material that can be incorporated in tutorial sessions.

One of the aims in computerising the Museum of Tropical Medicine was to make its contents more widely available, particularly in developing countries. [King & Beck 1990] stress the need for knowledge bases to be accessible and modifiable in such applications and for this reason, we have developed a range of authoring tools that enable the Tutor to be easily adapted to a range of different medical environments.

2. Structure of the Clinical Challenge System

Figure 1 illustrates the main features of the Clinical Challenge System. The disease Database is central to the operation of the Challenge System. Each disease entity is represented in the Database by a frame structure containing information about the symptoms, signs and management options for the disease. The data in the
Database is coded using a hierarchical taxonomy of symptoms, signs, examinations and laboratory tests. This taxonomy was devised to enable accurate cross referencing of disease features and to enable the design of a simple and natural system of menus for use by an expert when editing disease data and by a student in gathering data about a simulated patient. The medical expert enters symptoms, clinical signs and interventions using a data entry system called the Editor.

The Tutor generates simulated cases from the information in the Database and presents them to the student. The purpose of the Tutor is to give the student experience of the logical elements involved in data acquisition and case management. Each patient presents to the student with one or two presenting symptoms and the student participates in a data gathering exercise that simulates the consultation that would take place between a practitioner and a real patient. The student can also request lab tests and can specify a management plan for the patient. For example, the student 'questions' the patient about symptoms by using a hierarchy of menus. The patient's answer is presented by adding a card to the top of a stack of index cards that contain the information about the patient that has been gathered so far. In the examinations section of the Tutor, the 'menus' consist of a hierarchical set of graphical representations of the human anatomy. These replace the textual menu structure originally developed for SIMPLE LINCTUS. The student requests examination of some part of the patient by pointing first to the general region on the whole body graphic, then pointing to the appropriate part of the graphic representation at the next level of detail, and so on. Figure 2 illustrates the screen layout used during this process. The result of an examination is a textual description of a disease sign (if any). If a picture is available, a video camera icon appears on the relevant index card.

The tutor also checks and comments on any hypotheses made by the student about the patient's disease. This is done by cross-referencing the data gathered by the student against that for other diseases in the database. A set of tutorial rules analyse and comment on other aspects of the student's actions.

In addition to the database Editor, the flexibility of the system is further enhanced by the provision of two further editing tools: a Meta-editor for changing the structure of the data in the Database and a Rule-editor for modifying the rules that respond to various student actions. In subsequent sections we discuss, in more detail, the authoring tools developed in the Clinical Challenge System.
3. The Database Editor

The purpose of the Database Editor is to create a Database of disease frames for use by the Tutor. For each disease, the clinician has to enter information under each of the following headings:

- Disease Name e.g. Onchocerciasis
- Disease Presentation e.g. River Blindness, Central American
- Disease Group e.g. Infective and parasitic diseases
- Age groups affected
- Gender ratio affected
- Racial groups affected
- Symptoms
- Clinical Signs
- Illustrative video pictures
- Abnormal Test Results
- Management Plan

Apart from textual comments that can be added by the clinician, the entries in the Database are all represented internally as codes constructed using a coding system developed from that used in SIMPLE LINCTUS. As mentioned earlier, this coding system is based on a hierarchical taxonomy of symptoms, signs, examinations and laboratory tests. A precise coding system enables the accurate cross referencing of disease features used by the Tutor in creating and refining differential diagnoses. In the Clinical Challenge Editor, a simple spreadsheet format in conjunction with menus of options is used to enable the clinician to construct the disease feature codes in a friendly and natural way. Figure 3 shows an example of the spreadsheet and menu interface being used to input the description of a skin change symptom.

The menu structure for symptoms in the Editor reflects the taxonomy of the data stored in the Database. The same menu structure is used in the Tutor when the student is 'asking' the simulated patient about symptoms. The patient is asked about skin problems by working down the appropriate menu structure.

A similar taxonomy and menu structure is used in the Editor for describing the results of examinations (clinical signs), tests and management actions. However, in the Tutor, the menu structure is replaced for examinations by the hierarchical set of body graphics mentioned earlier.
4. The Meta-Editor

It is essential that the taxonomy used for describing disease features reflects the terminology used in the application area for which a tutor is being developed. Even during the development stages for the particular application area of Tropical Medicine, discussions with experts led to frequent restructuring of the data and of the menus. This process was greatly facilitated by the development of the Meta-Editor which permitted changes in the data taxonomy to be easily incorporated in the Database.

Each entity in the hierarchical taxonomy of the data (which also corresponds to an entry in one of the system menus) is represented by a record structure. This record represents that item's position in the hierarchy, and the way it fits into the menu structure. The Meta-Editor permits these records to be displayed in spreadsheet format, edited, inserted or moved around in the hierarchy.

5. Selection of Images

An important problem in the development of Tutoring Systems that access multimedia material is how to incorporate the available material in such a way as to provide effective but natural extensions to the tutorial process. The aim should be the 'seamless integration and synchronisation of media' [Mühlhäuser 1990]. In particular, slides used by the Tutor to illustrate particular points should be chosen for their appropriateness.

The bulk of video material available in the Museum is in the form of slides stored on videodisk. These slides are described in an Imagelist database that includes administrative information about source, copyright, etc. together with a few sentences of textual information about the content of each slide. The textual material provides optional captions for use with the slides when they are displayed on the screen. One level of indexing of the slides is based on their textual descriptions and this is sufficiently accurate for some purposes. For example, the authors of simple slide loops or tutorial presentations can choose the most relevant slide for their purpose from several presented to them in response to a query.

The Challenge System has more precise requirements. During a simulated consultation, in response to a question by the student about a particular aspect of the patient's condition, the Challenge Tutor must display an appropriate slide selected on the basis of accurate criteria applying to the current patient's problem. The solution currently implemented is for the medical expert to use the Database Editor to link clinical signs with appropriate video slides. Two modes of search for doing this are currently implemented within the Editor. Manual search allows the user to browse the disc from a specified frame number in the hope of finding a relevant picture. Any number of example pictures can be attached to a given clinical sign in this way. Frame numbers of possible pictures can be found using the textual indexing software mentioned above. The next level of search implemented in the Editor involves more accurate indexing of video pictures. Additional fields in the image database permit a more precise tagging of pictures with keywords indicating the nature of the clinical sign.
depicted. Providing the images have all been tagged in this way, the facility exists within the Editor to do a more accurate keyword search for images to illustrate particular clinical signs.

With the current level of indexing of slides, the burden of checking the relevance of slides selected by the Editor is still placed on the medical expert who builds up the Challenge disease Database. An even more precise classification of the images would, in the future, enable more accurate selection of images, possibly by the Tutor itself during a simulated consultation. An enquiry could be constructed automatically from the coded description of any clinical sign that results from an examination requested by the student. This enquiry could then automatically select an appropriate picture for display to the student.

The original task of tagging many thousands of clinical slides for indexing is itself a massive job for a clinical expert, but once this has been done to a slide collection, the collection becomes a much more valuable resource. Such precise indexing of large image collections will be essential in the future for their effective use by CAL and Tutoring software.

6. Tutorial Rules and the Rule-Editor

Much of the tutorial interaction of the system is triggered by implicit rules. These are handled as part of the general tutorial strategy, for example whenever the student refines his/her differential diagnosis list by adding or deleting an hypothesis. If the cross-matching of disease features acquired by the student so far suggests that the hypotheses change being made is inappropriate, then the Tutor will intervene with a suggestion to that effect. Similarly, management actions that are specifically linked to a particular disease are stored explicitly in the disease Database, and are tagged as 'Mandatory', 'Optional' or 'Harmful'. Again, these are not the subject of specific tutorial rules, but are handled by the general tutorial strategy when a student's proposed management plan is assessed.

The Rule-Editor currently permits the clinician to create or modify three types of explicit rule. These are common sense rules together with the two categories of examination rules. The rules that link examinations to disease categories can be created and edited in a similar way.

- Symptom-examination rules indicate which examinations are appropriate for given groups of symptoms. (Recall that symptoms are disease features that have been noticed by the patient and communicated, possibly under questioning, to the doctor.) An examination will be permitted without comment only if it is appropriate for the symptoms that have been communicated to the student so far in the current case study. For example, Figure 4 illustrates the creation of a rule that indicates the body systems that it is appropriate to examine if symptoms involving skin changes have been presented by the patient.

- Disease category-examination rules indicate which examinations are appropriate for each category of disease. (Diseases are grouped into broad categories such as 'Infective and Parasitic Diseases',
'Diseases of the Nervous System', etc.) An examination will be permitted without comment only if it is appropriate for the diseases that the Tutor has not yet eliminated from its differential diagnosis list.

- Common sense rules are linked to particular laboratory tests or management actions. A typical example might be the common-sense rule: don't prescribe contraceptives for a male patient. Other such rules might indicate harmful drug interactions.

7. Conclusions

We have described a set of software modules that enable the creation of a flexibly structured Database of disease data and a set of tutorial rules. The databases created are then used to drive a tutoring system that presents case studies to students and comments on their performance in handling the case studies.

The flexibility of the system is now being assessed by converting it from its initial application area, Tropical Diseases, to that of Primary Care in the UK.

Further research is now being conducted on extending the tutoring interaction to cover observational skills when students are presented with pictures of disease features without accompanying textual descriptions.

8. References


Abstract: The purpose of this study was to develop a practitioner-validated list of competencies needed by educators to author multimedia courseware. A four round Delphi survey using electronic mail for all communication was the method used to collect data. A list of sixty-three specific competencies guiding this study was derived from the recent literature on authoring multimedia courseware and was verified by a panel consisting of eight multimedia-using experts, Panel A, in Round One of the study. Based on the panel’s responses, all competencies were accepted without significant revision. This verified list of competencies was then rated in three subsequent rounds by Panel B.

Authoring is a term that applies to a set of computer programs and languages that allow the user to write or "author" courseware [Newby, Stepich, Lehman, & Russell, 1996; Davis & Budoff, 1986]. Authoring software allows teachers to create interactive, computer-based multimedia programs and presentations without knowing a formal programming language such as Pascal or BASIC. Davis and Budoff [1986] contended that authoring programs were developed to satisfy the needs of educators who want a relatively simple method for constructing customized, computer-based instructional materials.

Lockard, Abrams, and Many [1994] listed several reasons why teachers may find it advantageous to develop their own software. First, teachers may not find appropriate software since educational software companies must develop software that meets the needs of many students in order to be cost-effective. Newby et al. [1996] cite this reason as a major justification for using authoring software. Second, budgetary considerations may prevent teachers from purchasing a commercial software package. Third, educational software is not designed with specific students and individual needs in mind. Finally, teachers may have a personal preference for creating their own materials including the natural desire of experienced teachers to produce their own educational materials of all kinds.

Teachers are logical developers of courseware for their classrooms since they have a better knowledge of the content than do commercial software designers, and they bring to the authoring environment their knowledge of good pedagogy and teaching skills. Teachers also have the concrete experience of actually teaching the content and have learned by experience what strategies work and which ones must be reinforced in multiple ways. Teachers understand the needs of their audience better than anyone else. Kearsley [1986] suggested that teachers should author their own programs in order to become better software evaluators. He stated that the ability to distinguish a good software program from another is one of the critical skills needed by software designers. He continued by adding that evaluation skills and design skills are mirror images of one another.

Instructional technology courses for educators that are offered in authoring courseware vary greatly in content, objectives, and goals. There is a lack of consensus and no clear cut guidelines concerning the knowledge, skills and competencies which should structure a program in authoring multimedia courseware for classroom use among professionals in the field.

Design of the Study

Procedure
To achieve the purpose of this study, the following research questions were investigated:

1. What does the recent literature describe as the competencies needed to author courseware?
2. What authoring competencies are identified by a panel of multimedia-using practitioners as necessary to author courseware?

Two panels of multimedia practitioners were used in this survey. Panel A consisted of eight experts in the field of multimedia design. All the members were active in the field of multimedia through their teaching activities, multimedia projects, and publications.

Volunteers for Panel B were solicited from nine educational listserv groups and the editorial boards of three educational technology journals. Panel membership was limited to those volunteers who had multimedia authoring experience. Seventy-three volunteers qualified.

All communication with panel members was conducted using electronic mail. Electronic mail offered several advantages in a survey technique of this type over other possible forms of communication: speed of delivery, cost-effectiveness, convenience to panel members, and greater accuracy of response [D’Souza, 1992; Ehrmann, 1990; Townsend, 1984].

The Delphi survey consisted of four rounds. In the first round, the researcher sent a list of 63 competencies derived from a review of recent literature to members of Panel A; the panel members verified the list and returned it. The competencies were accepted without significant revision and were then sent to the members of Panel B. In each of the next three rounds of the survey, members of Panel B rated the competencies, then returned the survey, and the researcher analyzed the responses using a HyperCard stack, Delphi Statistical Tool, and then returned the results to the panel for the next round of the survey.

Consensus and Stability

The goal of most Delphi surveys is to reach a consensus of opinion, and statistics that reflect convergence around the median are often used. In this Delphi, consensus was assumed to have been achieved when 100 percent of the votes fell within the interquartile range, the difference between the 25th and 75th percentage in the frequency distribution. The degree of consensus developed by Faherty [1979] was also used. Delphi items that received a quartile deviation of ≥.60 were considered to have achieved high consensus. Items which received >.60 and ≥1.00 were defined as having achieved moderate consensus. The premise underlying the Delphi technique is that by the final round of the survey, the quartile ranges of the scores for each competency will have diminished to a smaller interval, i.e. the quartile deviation will become smaller. It is usually asserted that this statistical phenomena indicates a more concise agreement among the participants [Faherty, 1979].

In addition to consensus, the stability of the panel’s responses from Round Two to Round Three and from Round Three to Round Four was also measured and evaluated. Stability is a useful means of determining whether panel responses have stabilized and will avoid forced consensus through subsequent rounds. The measurement of stability is expressed as a percentage and is defined as the number of net person-changes of votes divided by the number of panel members. Based on the recommendations of Schiebe, Skutsch, & Schofer [1975], any two distributions that attained stability measurements of less than fifteen percent were considered to have achieved stability since percentages up to fifteen percent represent the normal movement of a panel’s votes.

In analyzing the data received from members of Panel B during the final three rounds of the study, the following guidelines for rating the competencies and determining both consensus and stability were used:

1. A competency considered to be “critical” among the panelists would be one that received a mean score of 5.5 or higher on a six-point scale by the final round. A competency rated “very important” would be one that received a mean score between 4.5 and 5.49. A competency rated “important” would have a mean that fell between 3.5 and 4.49. Competencies that were rated between 2.5 and 3.49 would be rated “somewhat important.” Competencies would be rated “slightly important” if the mean fell between 1.5 and 2.49. Finally any competencies whose mean fell between 1.0 to 1.49 would be rated “not important.”
2. A competency that received a quartile deviation of >.60 was considered to have achieved high consensus. A competency that received a quartile deviation of >.60 but ≤1.00 would indicate moderate consensus. The rationale behind this assumption was the fact that a deviation of less than 1 point on a six-point likert scale would indicate a close clustering of scores and thus represent consensus.

3. Stability would be determined to be achieved when the total stability for the round fell below 15 percent.

Rounds of the Delphi Survey

Round One

From a review of the major education, multimedia, and authoring literature, a series of 63 competencies were synthesized relative to graphic design, instructional design, and basic authoring guidelines. Panel A was given this initial list of competencies. Panel A was not asked to rate the competencies but simply to accept, delete, or edit. The list of competencies and the accompanying cover letter was sent to panel members electronically with a 5 day return deadline. There were no major changes or deletions of competencies. These revised competencies formed the basis for the Round Two list of competencies.

Round Two

The Round Two survey and a brief set of directions were sent electronically to Panel B members. Panel members were asked to rate each competency on the following Likert-like scale: 1=Not important, 2=Slightly important, 3=Somewhat Important, 4=Important, 5=Very Important, 6=Critical.

Panel members were given a six day deadline to return their rated surveys. Out of a possible 73 participants, 60 (82 percent) of the panelists responded to the Round Two survey. Panel member’s ratings of each competency were recorded using a HyperCard stack, Delphi Statistical Tool developed by Holden [1992]. The Delphi Statistical Tool (DST) computed the statistical analysis of the Round Two responses, including the mean, median, interquartile range, and quartile deviation for each competency.

Out of 63 competencies in Round Two, 57 competencies, or 90.5 percent, achieved consensus. Because complete consensus was not reached, and stability could not be measured on a single round, the survey was sent again to Panel B members.

Round Three

In creating the Round Three survey, the Delphi Statistical Tool provided two pieces of information for each item: the interquartile range of the complete panel’s ratings and the individual panel member’s rating for each competency. The instructions for this round noted that the responses of the majority of panel members were denoted by placing numerals in parentheses to indicate the interquartile range, the range of scores that fell between quartile 1 and quartile 4. The prior rating of the individual was indicated by an “x” directly over it. For example:

The educator should be:

\[ x \]
\[ 1 \quad 2 \quad 3 \quad (4\quad 5) \quad 6 \quad \] 5. able to identify instructional need.

In Round Three, each panel member was asked to rate each item again, noting the interquartile range of the competency in relation to the panel member’s previous rating. A six day deadline was again used.

Fifty-seven panel members (95 percent) returned the survey within the allotted time. The three non-respondents were not sent the Round Four survey and were not included in the final data analysis. The responses of each panel member were again recorded and analyzed using the Delphi Statistical Tool. Because two rounds had occurred with the same panel, stability could also be computed.
Out of 63 competencies, 62 competencies or 98.4 percent achieved consensus. The total stability between Round Two and Three was 14.5 percent. This was an acceptable level of stability, but since complete consensus was not reached, the survey was sent again to Panel B members.

Round Four

The Round Four survey was created in the same way as Round Three. All Panel B members (100 percent) responded to the Round Four survey within a six day deadline. The responses of each panel member were again recorded and analyzed using the Delphi Statistical Tool and stability computed. Out of 63 competencies, 100 percent achieved consensus. The total stability between Round Three and Four was 8.8 percent. Thus, with this high degree of consensus and stability, the collection of data was concluded.

Results of the Study

Through the Delphi rounds, the number of competencies that achieved either high or moderate consensus (quartile deviation of $\pm 1.00$) increased significantly [Tab. 1].

<table>
<thead>
<tr>
<th>Consensus</th>
<th>Round Two</th>
<th>Round Three</th>
<th>Round Four</th>
</tr>
</thead>
<tbody>
<tr>
<td>High consensus</td>
<td>2</td>
<td>27</td>
<td>45</td>
</tr>
<tr>
<td>Moderate consensus</td>
<td>55</td>
<td>35</td>
<td>18</td>
</tr>
<tr>
<td>No consensus</td>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>57/63</td>
<td>62/63</td>
<td>63/63</td>
</tr>
<tr>
<td></td>
<td>(90.5%)</td>
<td>(98.4%)</td>
<td>(100%)</td>
</tr>
</tbody>
</table>

Table 1: Consensus of Competencies

Analysis of this data revealed that importance ratings were moderately high. The mean value ranged from a low of 1.68 (slightly important) for Competency 3-1, "The educator will be cognizant of programming languages (Basic, Pascal, C++, Logo) and concepts," to a high mean value of 5.61 (critical) for Competency 2-18, "The educator will be able to identify and understand the needs of the target audience."

One competency was ranked as "critical." A total of 25 competencies were ranked as "very important" (mean between 4.5 and 5.49) while 32 competencies were ranked as "important" (mean between 3.5 and 4.49). Therefore, of the competencies identified in the literature by the researcher, 58, or 92 percent, were ranked in the upper half of the rating scale (mean score 3.5 or above). Only five competencies received ratings with means less than 3.5.

Research Questions

What does the recent literature describe as the competencies needed to author courseware?

A total of 63 specific competencies guiding this study were derived from the recent literature on authoring multimedia courseware. This review of literature included books and journal articles on specific issues in multimedia design and included three basic categories: graphic design, instructional design, and specific authoring requirements. These competencies were verified by a panel consisting of eight multimedia-using experts, Panel A, in Round One of the study. This panel was given the opportunity to revise this list of competencies. The fact that very few of the panel members chose to do this suggests that the review of the literature captured the data accurately. Based on the panel’s responses all competencies were accepted without major revision.

What authoring competencies are identified by a panel of multimedia-using practitioners as necessary to author courseware?
This question was answered based on the responses of Panel B. The verified list of competencies was rated in three subsequent rounds by a larger panel of multimedia-using practitioners, Panel B. The list of competencies were rated using likert-like scale of 1, "not important", to 6, "critical."

Only one competency was determined to be "critical" (mean score of 5.5 or above): The educator will be able to understand and identify the needs of the target audience. This competency was consistently rated as "critical" throughout all three Delphi rounds, and the mean score steadily increased in each round. There was high consensus on the rating of this competency throughout all three rounds.

**Competency Ratings**

There were 25 competencies (40 percent) identified as "very important" (mean score between 4.5 and 5.49). The second highest rated competency was: The educator will be able to organize content in chunks and link those chunks in a meaningful way. Organizing content into "chunks" is a skill critical in designing any type of instruction. This skill is also rated as necessary by current writers on instructional design of multimedia.

The third highest rated competency was: The educator will be able to identify instructional need. This competency supports the need to identify both the target audience and the needs that audience has for instruction. The findings are also congruent with the current literature on instructional design.

The fourth highest rated competency was: The educator will be able to recognize the non-linear nature of multimedia and use it advantageously. This competency was consistently rated as "very important" throughout all three Delphi rounds. This competency is the first time the term “multimedia” is mentioned in the competency itself. The three highest rated competencies relate directly to the target audience, their needs, and the need for instruction. This competency specifically relates to the method of presentation. Recognizing the non-linear nature of multimedia and then using it advantageously is perhaps the key feature in using multimedia.

The fifth highest rated competency was: The educator will be able to form broad course objectives. This competency is similar to the third highest rated competency: The educator will be able to identify instructional need. Overbaugh [1994] grouped the identification of need and the forming of broad course objectives as the starting points in designing computer-based instruction.

The sixth highest rated competency was: The educator will be able to organize and present information in a non-linear way. Presenting information in a non-linear way is a skill that many successful teachers have already developed even without using multimedia software and programs. Those teachers who have not acquired this competency could perhaps use multimedia to develop better presentation skills.

The seventh highest rated competency was: The educator will be able to analyze tasks. The ranking of this skill supports most of the instructional processes identified in the current literature. Overbaugh [1994] stated that the ability to analyze tasks is the next step that follows identification of instructional need, formulation of broad course objectives, and the examination of conditions that may affect knowledge acquisition.

In analyzing this data from the first seven highest ranked competencies, it is apparent that all of these competencies are related directly to instructional design and not specifically to authoring skills. These competencies are skills that a good teacher is expected to possess in teaching a content lesson regardless of the platform for instruction. Since good teachers already possess these skills of analysis and organization of content, teachers should have an advantage in designing multimedia courseware.

There were no competencies that were rated "not important" (mean score of less than 1.49). The lowest rated competency (mean score of 1.68 in Round Four) was: The educator will be cognizant of programming languages (Basic, Pascal, C++, Logo) and concepts. This competency was rated much lower than the next closest mean of 3.02. The debate over whether educators need to know programming languages has continued since the late 1980s when the number of students taking programming classes began to decline.

**Rating, Consensus and Categories**
In analyzing the general patterns of rating and consensus, several patterns begin to emerge. The higher rated competencies had a higher degree of consensus as a general rule; the competencies that had ratings below 3.5 had more fluctuations in consensus. The data did support the assumption in the design of the study that by the final round of the survey, the quartile ranges of the scores for each competency will have diminished to a smaller range. In the majority of the competencies, more concise agreement among the panel members was achieved in the fourth round.

If the competencies are loosely grouped into the three areas of instructional design, graphic design, and basic authoring skills, another analysis of data is suggested. There were 30 competencies that could be placed under the broad heading of instructional design skills. Out of these 30, 17, or 57 percent, achieved a ranking in the top half of the competencies ranked by mean score. There were 13 competencies that could be placed under the broad heading of graphic design. Out of these 13, 7, or 54 percent, achieved a ranking in the top half of the competencies ranked by mean score. There were 20 competencies that could be placed under the broad heading of authoring skills. Out of these 20, 7, or 30 percent, achieved a ranking in the top half of the competencies ranked by mean score. This suggests that the panel thought that instructional design competencies were slightly more important skills than graphic design competencies and much more than authoring skills.

Electronic Survey Research

Using electronic mail for communicating with panel members worked extremely well for this Delphi survey. The entire process of receiving, completing, and returning the rounds of the survey were completed with no major problems. Electronic mail offered many advantages in a survey technique of this type over regular postal mail. First, the speed of delivery was almost immediate. In fact, during one round, four replies from panel members were received before the entire group of surveys were completely sent out. Panel members could request and receive another copy of their survey form almost immediately if their survey was lost or misplaced. Second, the cost-effectiveness for both researcher and panel members was a great advantage. Third, electronic mail seemed more convenient to the panel members and enabled panel members who traveled out of town during the survey to still participate. Panel members seemed to appreciate the fact that they could receive information from the researcher quickly and be able to complete their survey when they were ready. Another distinct advantage in this type of communication is the fact that e-mail messages are usually read only by the receiver and not opened by an intermediary.

A high level of panelist interest was sustained during the course of the study, as was reflected in the high response rate during successive rounds. Out of 73 Panel B members, 60 (82 percent) responded to the Round Two survey. The third round produced a response rate of 95 percent, or participation by 57 members. The fourth round survey was returned by 57 members, or 100 percent. Total participation for the last three rounds of the survey was 78 percent.

High Ratings of Competencies

Many competencies (58 out of 63) achieved mean scores of 3.5 or greater. Throughout communication with members of both panels, it was suggested that there are many skills necessary to author a multimedia program, and authoring is best accomplished in design teams rather than by individuals. In design teams, assignments are divided among several individuals who possess specific skills. For example, on a design team there is usually a project director who is oversees the entire production, a content specialist who ensures that the program incorporates accurate and relevant content, an instructional designer who analyzes the learners, the content, and the desired outcomes, a graphic designer who brings together all of the graphic elements in the program, programmers who write the actual program for the computer, and, if needed, other specialists in video, sound production and animation.

In a classroom situation, however, the educator is forced to be a one person design team. This requires the educator to possess some of the skills that each member of the design team should have: an overview of the entire scope and sequence of the program, an accurate idea of the content and the way that it should be organized, the ability to find and utilize graphics and develop a graphically pleasing screen design and interface,
knowledge of the actual authoring process, and numerous other skills related to adding video, sound, and animation as needed. Can an educator be expected to achieve all of these skills? Perhaps this initial rating of competencies can help establish the beginning framework for developing a model for multimedia authoring.

References

Abstract: The purpose of this study is to examine features of multimedia materials that best support off-screen communication. Participants were twenty-one pairs of ESL students at the intermediate level. They were videotaped during on-line sessions over a two-year period. Results showed that multimedia genre and task type play a determining role in if and how students interact with one another while working with multimedia materials. It was found that still picture applications appeared to promote more intensive off-screen conversation than video. External tasks such as discussion, comparing, and joint composition provoked the largest quantity and best quality of discourse. Patterns of student-student interaction also suggested that teacher support and assistance contributed significantly to sustained conversation.

Background

Research in the field of second language acquisition supports the notion that non-native speaker interaction contributes a great deal to the learning of another language [Long and Porter 1985; Pica and Doughty 1986; Richards and Rogers 1986]. It is through meaningful and motivated interaction with others that a learner renders the target language comprehensible. Although multimedia technology can represent language in more richly contextualized and interactive format than other media, it is limited in terms of carrying on a "conversation" with the language learner. The technology cannot, therefore, provide individual learners with practice in the active negotiation of meaning that contributes to overall acquisition of the target language. An approach that potentially adds the communicative dimension to learning language with multimedia is the pairing of learners at the computer. Interaction between the two students, using the target language, would be the desired outcome. Thus far, however, results of paired-student interaction with the medium indicate the contrary: the machine appears to do more to get in the way of interaction than promote it [Meskill 1993; Piper 1987].

The Study

In an attempt to determine design features of multimedia that may be inducing or detracting from student-student conversation, this study examined twenty-one pairs of English as a second language (ESL) students who worked with multimedia materials designed to enhance listening, reading, and writing abilities in English. Pairs of intermediate level language learners were videotaped during one to one and one half hour on-line sessions over a two-year period. Students were assigned to work with each of the eight multimedia applications by the instructor of their intensive English as a second language, pre-academic program. These students represented similar ages and several different nationalities. They came in pairs to work with the multimedia applications from a single class. Each pair had had experience working with one another in a variety of paired tasks in the classroom, so came accustomed to working with one another.

Each session was videotaped. A two-part analysis of paired-student discourse was applied to the taped sessions: conversations were coded first by level of intensity of student conversation, then by the specific speech acts they performed while working with the multimedia materials. The first level of analysis, intensity, refers to student
behaviors and utterances. These include (in order of intensity level): silence, use of nonverbal signals, use of single words and phrases, use of simple complete sentences, and use of complex sentences.

The rationale for pairing language learners is that they would actively engage one another in sustained, involved interaction with the multimedia materials serving as a springboard for conversation. Through these conversations, learners would further develop their second language abilities. These conversations would, then, include more than gestures, noises, or single-word utterances. For the goal of active conversation to be met, learners would be engaged in producing both simple and complex sentences in their interactions with their partners. The last two intensity levels (production of simple and complex sentences), then, were considered to reflect more productive conversation than the first three. These intensity levels only provide information regarding form, not conversational intent. A second level of coding and analysis was therefore applied.

The second type of analysis, speech act analysis, focused on the following behaviors:
1. Repeating (repeating content in the multimedia application);
2. Managing the mechanical aspect of tasks (navigating, inputting);
3. Responding (agreeing or disagreeing with partner);
4. Showing concern for language form (talking about structure, vocabulary, etc.);
5. Inquiring (asking for understanding or opinion);
6. Stating one's own ideas (negotiating or challenging ideas);
7. Suggesting strategies or answers (negotiating or evaluating decisions, expressing cause and effect);
8. Showing emotion (e.g., complaining, apologizing, reassuring, and the like).

(adapted from [Abraham and Liou 1991]).

If the purpose of paired sessions with multimedia is to promote rich conversation, then the last three speech acts -- inquiring, stating one's own ideas, suggesting strategies or answers, and showing emotion -- are considered core acts. These forms of interaction are of a higher level, and therefore more conducive to the development of communicative competence in the target language [Abraham and Liou 1991]. These are also acts that serve to "keep the conversation going", a critical component when the goal is meaningful communication. A combined analysis of intensity and speech act type were used to determine the kind of conversation prompted by 1) specific genres of multimedia material; and 2) on-line tasks and off-line tasks.

The design approaches of the applications used by paired ESL students fall into five categories:
1. Simulation(1)
   Students navigate their way around a university campus by following directions provided by characters in video sequences. The goal is to find and check out The Castle, by Franz Kafka, at the university library.
2. Music videos (2)
   Students practice listening to and reading the lyrics of popular songs. They also practice the grammar and vocabulary of the video sequences in a variety of formats.
3. Comedy (1)
   Students view two American comedy shows with verbatim subtitles. They can control the pace and order of the sequences to hone their listening skills. Grammar and vocabulary practice is also provided.
4. Documentary (1)
   The documentary concerns whales. Students view the video with and without corresponding text. They can control and manipulate both text and audio sequences to practice listening, writing, reading, grammar, and vocabulary.
5. Open-ended stimulation (2)
   These applications present single pictures with accompanying audio sequences that match the visual. Tasks related to the pictures include writing descriptions, comparisons of pictures, and essays, matching the audio with the still and cloze exercises.

All applications involved directed practice with listening comprehension, reading, writing, structure, and vocabulary. An on-line English-English dictionary and a help function were available during all activities.

Outcomes: Genre

In examining multimedia features that support or discourage rich student-student interaction, we noted that the genre of the video portion of the multimedia materials seemed to be a strong determining factor in the amount and quality of student talk. The application that involved a video documentary appeared to provoke the least
amount of student conversation. Rather than talking about the content of the video and on-line activities that involved that content, students sat passively, paying very close attention to the information being presented in the video. This behavior supports the notion that the documentary genre is based on a "transmission of information" paradigm (Meskill, in press). Such videos are geared toward presenting information and as such cast the viewer into the role of receiver of that information. As such, it is not particularly suited as a springboard for extended conversation. This also appeared to be the case when the content of the application was music videos or comedy, genres aimed at entertaining and captivating individual attention, rather than promoting discussion. When working with the two aforementioned genres, students said little to one another and when they did speak, their utterances were consistently low level in terms of intensity. Their conversations did not include core speech acts. It seemed the voice of the video dominated the scene, rather than the students.

One might anticipate that the multimedia application designed as a simulation, the object of which was to find and check out a library book by "talking with" characters in the video, would stimulate interaction due to its problem-solving component. In these trials, however, students focused more on the speakers in the simulation than on each other. When it came time to make a decision based on the scenario, pointing and low-level utterances were the norm, rather higher-level, active negotiation. Individual preoccupation with an end product (solving the problem) appeared to take precedence over interacting with another about the problem and its solution.

The two applications categorized as open-ended stimulation produced quite a different picture of multimedia's role in promoting paired interaction. These applications focused student attention on single still pictures rather than video. They included short digitized audio sequences that went along with each visual. In each case, learners were prompted to explore and describe the pictures. They were invited to interpret the pictures in their own way by drawing from their personal knowledge repertoires and former experiences. During the trials, these visuals appeared to intrigue students' imaginations, provoke their thinking, and, in turn, stimulate conversation between partners. Because activities were based on personal interpretation, students were motivated to share these. This is in contrast to the video-based applications that focused on given information meant to be comprehended and utilized as such. Learners shared, revised, and built their interpretations jointly. Their utterances were consistently rich in higher level forms of intensity and in the frequency of occurrences of core speech acts.

Implications

The first three genres of multimedia material appeared to discourage student modification of the meanings ascribed by the presentations in the video sequences. These presentations left no room for learners to express their own ideas and opinions. The two still picture applications, however, apparently invited alternative interpretations on the part of the learners. Content was modifiable because it encouraged new perspectives and new voices. The form that information ultimately takes in an open-ended design is determined by the learner, not by the system.

Outcomes: Task Type

Considered alone, open-endedness of the visual genre in the multimedia material does not necessarily guarantee intensive interaction between paired learners. System-internal tasks also must be considered. Tasks posed by the application can be viewed as either inviting thinking and alternative interpretations or not. For example, multiple choice questions or cloze exercise leave little room for students to express their ideas in extended discourse. Tasks like problem solving, while requiring students to understand material in order to come up with a solution, concentrate on the end result, rather than on conversation. These tasks focus student attention on inputting and receiving feedback on what they type or click on, not on speaking to one another.

In these trials, those tasks that students were prompted to carry out off line (e.g., discussing, comparing, joint composition) stimulated the most off-screen interaction. The stimulus for the activities was on-line. Talk occurring about the stimulus was intended to take place off-line between partners. These system-prompted "external tasks" provoked the largest quantity and best quality (using the discourse coding system described above) than any of the other tasks in which paired students engaged. These results support the rationale for open-ended design when student-student interaction is the goal (see also Young, 1988 for similar observations concerning open-ended software design).
Teacher Support

In examining video genres, we found that video could affect passive reception and, in the majority of cases, worked to exclude the possibility for student-student interaction. Tasks too, if system internal, seemed to work against conversation. However, the discourse that did and did not occur between students took place in a clinical, not a classroom setting where the teacher might be present to encourage and support students communicating with one another. In one of the clinical trials, for example, a student who was a more advanced speaker of English than her partner took on the role of a teacher/mentor in the pairwork. The resulting dialog was, consequently, rated as more intense and complex than trials in which pairs were on more equal footing with the language.

The role of a teacher or mentor is indispensable in any learning process. This is especially true when students of differing cultural and linguistic backgrounds are paired with computer assisted instruction with the anticipation that they will converse. When learners lack the linguistic tools and cultural background information, teacher support is crucial to keep that conversation going. Teacher support for paired student discourse can take the form of modeling. By modeling the specific kinds of language learners need to keep the conversation going, the teacher can help student overcome the draw of the computer screen and keyboard in favor of speaking to one another. She can demonstrate speech and behaviors that students imitate in establishing and maintaining conversation with one another. Without an ongoing resource like teacher modeling, students have no human voice to turn to adjust or repair their communication. With a teacher providing models as students need them, conversations can be enabled.

Another form of teacher support is simple, ongoing guidance. When learners are at a loss as to how to proceed, the teacher can guide and encourage the continuation of the three-way conversation around the multimedia materials. She can also refocus students' attention back to the task, and back on the off-line conversation when breakdown occurs. By making suggestions and posing questions the teacher can encourage students to verbalize, rather than work "alone together" as was most frequently the case when a teacher/mentor was not present.

Conclusion

Examination of these paired language learner trials suggest that the following factors may play a determining role in if and how students interact with one another while working with multimedia materials: 1) materials genre (video genre, stills); 2) task type (internal, application-driven versus stimuli for external tasks). It might be concluded that, when the goal of pairing students with multimedia is student-student interaction, materials must include tasks that are meaningful, open-ended and that invite multiple interpretations so as to give students room to have something of their own to express. Tasks that challenge students' critical and creative thinking will do more to provoke talk than will listening/viewing comprehension activities. Patterns of student-student interaction also suggest that teacher support and assistance may work to mitigate against these two factors when these are working against sustained conversation.

While language instruction aims to develop reading, writing, listening, speaking, and pronunciation, the most challenging of these skills (the latter three) are best exercised in face to face interaction. Multimedia is an excellent self-study tool for practicing the structural/mechanical aspects of the target language. The medium is, moreover, particularly well suited for individual language learners to develop listening comprehension skills, a form of rehearsal for face-to-face conversations. However, if the purpose of on-line sessions is to stimulate and support the active negotiation of meaning with a human interlocutor, these trials suggest that this will best be affected when there is openness in material and task design complemented by active, ongoing support by a teacher/mentor.

References


A Software Tool for Educational Research in Pictorial Communication

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Abstract: We present here a system developed to serve the needs of educational research on pictorial communication systems. Questions can be differently scheduled by the researcher, the presented material can be arranged in different ways, pictures, diagrams, sound, texts can be fed to the system’s modules. The students' answers are automatically registered and can be processed or inspected directly. The software was preliminary tested, on a cognitively and educationally analyzed application, in classroom conditions. Minor changes and improvements followed.

Introduction

When designing, developing and using technology for education a good number of questions arise concerning pedagogical and didactic issues. The educational research is usually carried out with the traditional tools (questionnaires). This practice includes an inconsistency between the educational means and the testing means. In the bibliography, we find, some implementations for specific questioning. We, also, find extended use of general purpose software for statistical analysis or visualization of results. These tools strongly suffer from data entry difficulties.

We present here a system developed to serve the needs of educational research on pictorial communication systems. Questions can be differently scheduled by the researcher, the presented material can be arranged in different ways, pictures, diagrams, sound, texts can be fed to the system’s modules. The students' answers are automatically registered and can be processed or inspected directly.

The software was preliminary tested, on a cognitively and educationally analyzed application, in classroom conditions and minor changes and improvements followed.

In the following, we describe the design approach and the implementation of an application combining textual and visual information. The evaluation procedure is, also, presented.

Design Approach
We have applied the rules of prototyping keeping in mind that the product should be used for educational purposes [Smith 1991], [De Diana et al. 1994], [Ellis 1993]. The result could be useful to educators as well as to system designers. The different users, the varying needs of educators and the fact that the multimedia material is quite expensive and not always standardized are some of the reasons which led us to an open system approach. For the operation and the structure of the system we made the following assumptions:

- An application has its own philosophy and must be cognitively and educationally analyzed before the implementation.
- The students interact with the system for different tests on the same material and are always traced for achievements.
- The results are inspected and analyzed in various ways by the educators.

These assumptions are incorporated in the five modules which constitute our system [Fig. 1].

Description of Modules

Content

The testing strategies module (TSM) includes the various ways the student can be tested and the navigation techniques. Its content is the result of the cognitive and educational analysis of the specific application. The analysis and introduction of several applications can create a knowledge of student testing which can reside in the system, transferred to the information module.

![Diagram of the Modules of the Software](image)

The information module (IM) contains all the information needed for the research. A part of it can be the above mentioned knowledge. Generally, it contains all the material, the TSM is making use.

In the student recording module (SRM) all the student’s reactions and answers, when interacting with the system, are registered. The introduction of long phrases or paragraphs is accepted by the system. In this way, the quality answers, which are usually evaluated by inspection or reading, are already in the system.

The processing of results module (PRM) contains the general purpose software needed for this type of work. Those can be statistical packages, programs for graphics or just the visualization of the SRM content.

The communication module (CM) contains all the linking between the four main modules. This module is, also, the interface with the three possible users: the designer, the educator and the student. The system-user interaction is differently designed for each one of them.
Interaction

The designer can interact with the system for updating or improvement. The student interacts with the system for testing and his answers and reactions are recorded on his own file in SRM, to which he himself has no access. The educator introduces the testing strategies (in case he is not familiar this can be done by a computer user). He introduces, too, the material needed for his research. After the students test, the educator interacts with the SRM and PRS. The educator is the only user allowed to access all the five modules.

Technical characteristics

In the IM module images, diagrams, texts and other material are stored. Software under test or information retrieved from a distance can, also, be included here. The development station was a Multimedia 486DX2, 16MB RAM, 500MB HD containing Visual Basic 4.0, a Word Processor, statistical packages, graphic tools for the visualization of results, the scheduling of tested material etc.

Application

The pictorial communication systems [Ellis 1993] raise issues which need investigation from the educational point of view. Some of those issues were detected during the designing of educational software tools [Metaxaki et al. 1994], [Metaxaki et al. 1991a], [Metaxaki et al. 1991b], [Metaxaki et al. 1995]. Nowadays we have an extended use of images, diagrams and bar-graphs illustrating texts. The diagrams are pictorial representations of information and combined with the textual information, support the dual coding learning [Mayer et al. 1992], [Mayer 1993], [Moore 1993]. We have chosen exactly this topic for our application.

Cognitive and Educational Approach

The student performance for understanding and successful learning of graphs and diagrams, depends on the mental representation and the metacognition skills. The active learning is supporting the metacognition skills and leads to better understanding. The mental representation depends on the ability for cognitive processing. An efficient strategy for the use of graphs can create connections between the textual and visual information to support the ability for cognitive processing.

[Fig. 2] shows all the mentioned dependencies which present a strategy for achieving best performance. The presented application refers to the shaded part. The processing of results of a good sample of students, specified by an educator, can lead to valuable conclusions for the support of mental representation and metacognition.
Figure 2: Dependencies for visual learning

Modules Functioning

Before testing the students, the modules must be prepared to function properly.

The TSM and SRM modules are adjusted to the testing strategy and to record the student’s reaction accordingly. The student testing realizes the goal directed exploration in interactive way [Schank 1994], [Ambron and Hooper 1990]

[Fig. 3] shows the scenarios for the user trials realizing the strategy of [Fig. 2]. Three modes of a graph presentation (continuous availability, on call, integrated in a page) and two modes of a text presentation (sentence by sentence, page by page) are combined for the student trials. The combinations and the connections are represented by oriented lines. The dotted lines show acquisition of indirect information i.e. the frequency of inspecting a graph through an on call mode is direct information, while the frequency of inspecting a graph integrated in a page text mode is indirect information.

We have to declare the connections starting from the continuous availability box. The where and the frequency are meaningful only when the student reacts to: “where is the best position of the graph”, “mark the points in text, the graph is matching best”.

The student interface of the CM is activated to serve the testing needs and the student’s rhythms [Blattner and Dannenberg 1992], [Kobsa and Wahlster 1989]. The screen design is based on the contiguity principle [Mayer et al. 1992] for simultaneous representation of visual (graph) and verbal (text in space) information.

[Fig. 4] shows a screen for the first test. We can distinguish between two screen areas. The interaction area and the information area. Through the first the student interacts with the system and the interactions are transferred
to SRM for automatic recording. The information area includes the textual and pictorial sub-areas which, according to the presented scenario, are separate or merged. In the interaction area, there are buttons (or icons) for interaction and program control. The student can call or suppress the graph, mark the logical connections etc. On the information area, the text is about the content in carbon of various coals. The bargraph is presenting visually a part of this information. On this screen the textual and pictorial area are separate but on the same sight level.

Student’s Trials

The user trials are grouped in two. One group for the student’s skills (SSK) on using graphs and one group for the student’s understanding (SUN). We give an example of two scenarios for each group:

SSK1: A text is presented sentence by sentence, the abstract of the text and the graph are available on call. The frequency of calls and the duration of the observation (overall time, every case time) are recorded [Fig. 4].

SSK2: A three page text is presented sentence by sentence, the graph is available on call. The frequency of calls, the text points of this occurrence and the duration of inspection (overall time and every case time) are recorded.

SUN1: A text of three pages is presented sentence by sentence, a graph is available continuously. The text points best represented by the graph, are marked and recorded.

SUN2: A text of four pages is presented page by page, a graph is integrated in the third page (graphpage). The number of the references to the graphpage, the tracing of the pages, the duration of graphpage observation and the overall time are recorded.

Figure 4: A screen design example

The texts were different for every case. Free writing texts are acceptable on educators instructions. The mentioned examples were repeated with animated graphs.

After the testing, we can find in SRM the registered parameters, as well as, the texts probably introduced by the students. The educator can access them visually (on the screen or printed). He can, also, make use of available software, linked with the system, for statistical analysis and/or visualization.
System evaluation

The system targets to be used by educators, for forming their tests, and students for their trials. Based on previous experience on evaluation, we proceeded to a dual evaluation one by educators and one by students [Kouroupetroglou et al. 1994].

We were addressed to two teachers who were computer users. We explained to them the system functioning and we asked them to prepare material and scenarios making use of the general purpose software and material contained in the system [Metaxaki et al. 1991a]. They selected representative maps of Greek areas and edited texts. They checked the system for usability, familiarity, implementation capability, interaction. We talked with them about the product conception. Their observations and remarks were very helpful to improve the system. Their remarks concerned mostly the SRM and the presentation of testing results.

The scenarios scheduled by the two teacher’s, were used for testing student’s in classroom conditions. We have selected fifteen students between fourteen and fifteen years old. In this age, the students in Greek schools, are moving from lower secondary education to higher secondary education. The marks, of all these students, were about the average for the topic of the test. They were familiar with the machines existing in their schools. Those machines were technologically lower than the development station, so we transferred the testing to this lower technological level. Concerning the use of visual information interpretation, their experience was quite poor as this subject is not always given special attention in classroom. The evaluation, among others, concerned the familiarity, the students interface, the interactive area. We got results registered in SRM which we have visually inspected. This evaluation helped us a lot to improve the student’s interface, especially the interactive area.

Discussion and Results

The software tool we propose, supports the educational research on pictorial communication issues. The system is open and accepts the material under test in different modes (images, diagrams, graphs, texts, sound). General purpose software, included in the system, can be used for developing scenarios and schedule test presentation and interaction.

The use of the system must be preceded by a cognitive and educational analysis, for the estimation of the user trial parameters and the strategy of testing. The functioning of the five modules is specified by this analysis. The content of the information module can be restored for a new application or make its content available in a different way, specified by the strategy and the scenarios kept in the testing strategy module. The reuse of the system can create a knowledge to facilitate the educator. The student’s reactions are stored automatically in the student’s recording module. The educator processes the test results without the data entry problems.

A step by step execution of the user trials is provided. This serves the intervention of the educator for instructions during the testing process. This can serve, also, to the linking with an advanced electronic questioning system. Sound is provided for oral instructions or further testing (audio - visual or audio - visual - textual). We are under continuous extension and improvement of the system to gain in usability for educators.

This type of a system was very well accepted by the educators we collaborate with. Also, some designers working on the field of pictorial communication, found it quite interesting, as a tool for pre-design investigation.

References


The Effect of On-Screen Instructor Gender and Expressivity Upon Adult Learning of Basic Skills from a Videotaped Lesson

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Abstract: This study determined the effects of on-screen instructor gender and expressivity upon learning. A 2 x 3 factorial design was used. The independent variables were instructor gender and expressivity. The dependent variable was student learning. Students also rated instructors' expressivity. The subjects (n=120) were underemployed or unemployed adults. Six videotapes were produced. They were identical, except that in three tapes an actor behaved in low, average, and high expressive manners, while an actress performed in low, average and high expressive manners in the other three. A significant interaction was found between on-screen instructor gender and expressivity, as measured by the subjects. Subjects viewing the unexpressive male and the highly expressive female scored highest on the exam. Students viewing opposite gendered instructors scored highest on the exam. This study suggests that the audience's gender and perception of the instructors' expressivity be considered in the design, casting, and directing of television programs.

Introduction and Statement of the Problem

Since on-screen talent occupies such an important position in communicating the content of any video message, the most effective characteristics of these individuals need to be identified. The selection of appropriate talent presents an interesting dilemma for video producers and directors. Past traditions of our society suggest that unexpressive males, or somewhat strict authority figures, have a positive impact upon gaining and holding viewer attention. As a result, in the past, men have been preferred by most producers and directors. However, our traditional views of the roles of men and women are in a state of flux. Have these changes affected the ways in which talent should be chosen and directed to behave in front of the camera and microphone?

As societal roles change and as more women enter non-traditional female career areas, stereotypes may change, or even disappear [Basow et al, 1985]. Should the choice of the talent be based exclusively upon the hoped-for effect on the audience? Further, should the producers assume an iconoclastic role by taking the lead in breaking these cultural stereotypes and biases, even if this posture diminishes the effectiveness of the video message? Beyond the gender of talent, the question of how actors should perform in front of the camera and microphone is crucial to the success of any video production. Should talent be warm and expressive to gain audiences’ attention, or should they be aloof and objective to communicate the importance of the message? Some research [Rogers, 1961]; [Chu et al, 1967]; [Rossiter, 1972]; [Brend, 1975]; [Gilbert, 1981]; [Knowles et al] in [Darkenwald et al, 1982]; [Fassler, 1989] suggests that in a classroom setting, warm, nurturing teachers bring out the best in students. Others [Watson, 1924]; [Thorndike, 1932]; [Skinner, 1968] are equally convinced that strict, direct, no-nonsense teachers enable students to give their best.

De Beauvoir (1952) [Borrisoff et al, 1985] wrote that "... men (people) describe the world from their own point of view, which they confuse with the absolute truth" (p. 13). It is from this truth that our internalized masculine and feminine stereotypes have evolved. Television producers have long adhered to the common folklore that, men's words and opinions are more listened to, valued, and respected than are women's [Sachs, et al, 1978]; [Mattingly, 1991]. The presence of these biases is widely supported in the literature [Wolfram, 1974]; [Sachs, et al, 1978]; [Borrisoff et al, 1985]; [Mattingly, 1991]. Should producers continue to foster these stereotypes, or should they try to reeducate clients and audiences? Should the choice of talent be based exclusively upon the anticipated effect on the audience?

Review of Relevant Literature
Studies have consistently shown that television is an effective means of communication [Chu et al, 1967]; [Gagné, 1987]. The use of video-based instruction in schools, in the work place, and in the home is rapidly increasing. Very little experimental research has been done on the effects of on-screen talent gender and expressivity upon video-based learning. Hundreds of studies have been done on the design, production, costing, effectiveness and use of television [Schramm, 1977]. However, only three studies [Pearson, 1980]; [Chiddix, et al, 1981]; [Basow et al, 1985] have been found on the influence of an on-screen presenter's gender on learning. These studies were done with undergraduate college students as subjects. None of these studies address the effect of the on-screen instructor upon adult learning of basic cognitive skills. Producers of videotapes often expend a great deal of time, energy and money selecting talent. While many factors influence the selection of this person, few are based upon the research in the field.

Currently, those charged with designing and producing television programs are making uninformed decisions about who will appear in these tapes, and how they will act. Decisions are being made on the strength of preconceived cultural stereotypes, gender biases, common folklore, and purely empirical observations [Moore et al, 1985]; [Ferrante, et al, 1988]; [Edelstein, et al, 1989]. Therefore, the objective of this study was to determine the effect of on-screen instructor gender and expressivity upon adult learning of basic skills from a videotape.

Methodology

A 2 x 3 factorial design was used to analyze the variables’ effects on learning. The independent variables were instructor gender and instructor expressivity. The primary mediating variables were student gender and ethnicity (as measured by first language spoken). The dependent variable was student learning as measured by a twenty-question multiple choice exam. The subjects (n=120) used in the study were underemployed or unemployed adults enrolled in the Arlington, Virginia, Employment Training Center's clerical skills program.

The primary research questions addressed were:

1. What is the effect of on-screen video instructor gender upon the learning of basic computer skills by adults?
2. What is the effect of on-screen video instructor expressivity upon the learning of basic computer skills by adults?
3. What is the effect of the interaction between on-screen instructor gender and on-screen instructor expressivity upon the learning of basic computer skills from a videotaped lesson?

Six videotapes were produced. These tapes were identical in every way except that in three tapes a male actor taught in respectively low, average, and high expressive manners. In each of the other three tapes a female also acted in a low, an average and a high expressive manner. Each subject viewed one of the tapes in groups of eight to ten students and was immediately tested on the material presented in their tape. Students were also asked to rate the instructor they saw on a five-item scale of expressivity. Prior to the test, they filled out a twenty-question demographic survey soliciting information such as the subject’s age, gender, and their perception of the expressivity of the on-screen talent that they viewed.

Findings

Research question number one asked, “What is the effect of on-screen video instructor gender upon the learning of basic computer skills by adults?” No main effect was found for instructor gender (F=.06, p=.81). However, there was a significant interaction for instructor gender with student gender (F=4.56, p=.04). As Table 1, and Figure 1 indicate, students performed significantly higher when viewing tapes with instructors of the opposite gender.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MALE INSTRUCTOR</th>
<th>FEMALE INSTRUCTOR</th>
<th>COMBINED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Students</td>
<td>63.75, n=14</td>
<td>73.21, n=14</td>
<td>68.39, n=28</td>
</tr>
<tr>
<td>Female Students</td>
<td>68.37, n=46</td>
<td>64.35, n=46</td>
<td>66.36, n=92</td>
</tr>
<tr>
<td>Combined</td>
<td>67.25, n=60</td>
<td>66.42, n=60</td>
<td>66.83, n=120</td>
</tr>
</tbody>
</table>

Table 1: The Effect of On-Screen Instructor Gender on the Exam Scores of Students by Student Gender
Research question two asked, “What is the effect of on-screen video instructor expressivity upon the learning of basic computer skills by adults?” No main effect was found for instructor expressivity ($F=.02, p=.99$).

Research question three asked, “What is the effect of the interaction between on-screen instructor gender and on-screen instructor expressivity upon the learning of basic computer skills from a videotaped lesson?” No main effect was found for the interaction between instructor gender and instructor expressivity, as defined by the researcher ($F=.25, p=.78$).

However, when expressivity, as delineated by the subjects, was used in the analysis, significant relationships in the interaction between on-screen instructor gender and instructor expressivity were found ($F=5.17, p=.03$). As shown in Table 2 and Figure 2, students learned significantly better from the low expressive male and the high expressive female than they did from the high expressive male or the low expressive female.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>LOW EXPRESSIVE</th>
<th>HIGH EXPRESSIVE</th>
<th>COMBINED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Instructor</td>
<td>70.19, n=27</td>
<td>64.85, n=33</td>
<td>67.25, n=60</td>
</tr>
<tr>
<td>Female Instructor</td>
<td>60.80, n=25</td>
<td>70.43, n=35</td>
<td>66.42, n=60</td>
</tr>
<tr>
<td>Combined</td>
<td>65.67, n=52</td>
<td>67.72, n=68</td>
<td>66.83, n=120</td>
</tr>
</tbody>
</table>

Table 2: The Effect of On-Screen Instructor Gender and Expressivity on the Exam Scores of Students, As Perceived (Rated) by Subjects
Relationships between certain student demographic variables and the gender and expressivity of the on-screen instructors was also explored. Student ethnicity, as measured by first language spoken, was a meaningful indicator of success on the exam. Analysis of variance showed a significant interaction between instructor gender and student ethnicity (F=6.78, p=0.00). Table 3 and Figure 3 show the relationship between instructor gender and student ethnicity (as measured by first language spoken). Asian students scored higher on the exam when taught by the male than they did with the female instructor. Students indicating English, and students indicating Spanish, as their first languages scored higher with the female instructor than they did with the male instructor.

<table>
<thead>
<tr>
<th>INSTRUCTOR GENDER</th>
<th>Language (English)</th>
<th>Language (Spanish)</th>
<th>Language (Asian)</th>
<th>Language (Other)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>76.75, n=20</td>
<td>60.00, n=22</td>
<td>61.67, n=15</td>
<td>85.00, n=3</td>
</tr>
<tr>
<td>Female</td>
<td>80.59, n=17</td>
<td>64.79, n=23</td>
<td>51.00, n=15</td>
<td>72.00, n=5</td>
</tr>
<tr>
<td>Total Mean</td>
<td>78.51, n=37</td>
<td>62.45, n=45</td>
<td>56.33, n=30</td>
<td>70.69, n=8</td>
</tr>
</tbody>
</table>

Table 3: The Effect of On-Screen Instructor Gender and Student Ethnicity on Learning

![Figure 3: The Effect of On-Screen Instructor Gender and Student Ethnicity (as Measured by First Language Spoken) on Learning](image)
Implications

Designers of video programs must: (a) know the audience for whom they are fashioning their programming; (b) learn as much about that audience's demographic characteristics as is feasible; (c) do an in-depth analysis of the subject matter to be presented, always keeping their target audience in mind; (d) divide the content into easily digestible bytes for presentation within the video-based format; (e) attempt to match on-screen instructor characteristics with those audience attributes that will maximize the communication of their message; and (f) wherever possible, within the context of working with others on the content and production of the program, attempt to debunk stereotypical prejudices and cultural biases held by the organization and by the audience.

Who should the narrator be in a videotape designed to teach a group of adults beginning computer skills? The results of this study suggest that, with a population similar to one used in the study, if targeting a female audience, the narrator should be a man, and if targeting males, the narrator should be a woman.

How should talent perform in front of the camera? Should they be warm and expressive to build a sense of empathy with the audience, or should they act in a commanding or an imposing fashion to convey a sense of authority and therefore a sense of veracity? The results of this study clearly suggest that, for this population, learning this subject matter, female on-screen instructors should be directed, by video producer/directors, to act in a highly expressive fashion. Male on-screen instructors, teaching this population and subject matter, should be directed to behave in a low expressive fashion. Should the choice of the instructor be made exclusively on the hoped-for effect upon the audience? Great attention must be paid to the cultural biases and stereotypes of the audience. However, the practice of matching on-screen talent and audience based on stereotypical roles will not always succeed. Program designers and writers should not become so engrossed in their content specialties that they forget their larger societal role as a force of positive change. In addition, as more women and men enter non-traditional gender-related career areas, stereotypes may change, or even disappear. Should the designers of television programs assume an iconoclastic role by taking the lead in breaking these cultural stereotypes and biases? Not at the expense of the effectiveness of conveying the program's message! Management, sponsors, and ultimately the audience may rebel at the prospect of sermonizing. The induction of “noise” into the program may detract from the primary content/intent of your subject matter. The results of this study suggest that writers, directors, and producers of videotapes should know their audience.

Recommendations for Future Research

Based on the findings and conclusions of this study, the following recommendations are made:
1. This study should be replicated using a less complex subject matter. The task of learning the content in these videotapes may have been so difficult that the effect of instructor gender and expressivity may have been eclipsed.
2. This study should be replicated using the same six videotapes on a different population. The subjects in this study were all underemployed or unemployed adults. Forty-two percent of them had English language reading levels below fifth grade.
3. This study should be replicated using different male and female actors using greater degrees of expressivity. This may yield better defined group variances.
4. This study should be replicated using an exam that was less dependent upon cognitive abilities and more on competency-based learning.
5. This study should be replicated using shorter videotapes. This may enhance learning, which may result in a clearer picture of the effects of on-screen instructor gender and expressivity upon that learning.
6. To test the long-term versus the short-term retention of the material presented on the videotapes, this study should be replicated retesting the students on the information presented over a series of given time intervals.
7. The importance of student-related variables has been affirmed. Further research needs to be conducted on the interaction between instructor-related variables and student-related variables.
8. Investigations should be conducted into the role students’ language abilities played in success or failure on the exam.

This research was initiated because producers of videotapes were often making uninformed decisions about who will appear, and how they will act, in these tapes. Decisions were being made on the strength of preconceived cultural stereotypes, gender biases, common folklore, and purely empirical observations, and not on the findings of any known research on this topic. It was my intent to test the legitimacy of these cultural stereotypes and biases. In this way, writers and producers may at least begin to rethink their positions on whom they cast and how they direct actors in
programs. This research has, mainly, succeeded in bringing into question many of these practices, thereby improving the communications process between video producers and their audiences.

References

Virtual Knowledge Park: A Cooperative Learning Environment in Cyberspace

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Abstract: The project reported here is aimed at building a Virtual Knowledge Park as a site in the Internet, fostering interdisciplinary learning of science, technology, and human culture. The development of the Virtual Park requires a systemic approach in dealing with questions and devising solutions regarding four main areas: the content, the learning environment, learning processes, and technological features. The features of the first prototype of a wing in the Park are presented: it’s structure (namely exhibition, experimentation, and workshop areas, knowledge center and main general spaces); the activities allowed (e.g., activation of exhibits, cooperative on-line tasks); and future development and research lines.

Rationale for the development of the Virtual Park

The project reported here is aimed at building a Virtual Knowledge Park as a site in the Internet, fostering interdisciplinary learning of science, technology, and human culture. The development of the Virtual Park requires a systemic approach in dealing with questions and devising solutions regarding four main areas: the content, the learning environment, learning processes, and technological features.

Content

The epistemological approach guiding the selection of the Park’s content is the view of technology and the artificial as extensions, as well as facilitators for the development, of human capabilities [McLuhan 1964; Olson 1994]. Each content unit is treated integrating scientific and technological knowledge within a broad cultural (e.g., anthropological, philosophical, historical, social processes) milieu. The park is organized in wings, or thematic units. Each wing is organized around an issue or event of critical importance in the development of the human culture, e.g., turning points in scientific understanding of the world, or discoveries or inventions that affected individual and social life. Although a wing’s theme is always treated at all dimensions (namely science, technology, culture), given wings may have a leading conceptual entry point or key issue. Two examples currently under development are a wing on Galilee’s work (conceptual entry point: scientific transformations - see [The First Working Prototype of The Virtual Knowledge Park]), and a wing focusing on Gutemberg and the evolution of printing (conceptual entry point: technological transformations). Once in a wing, a systemic treatment of any given issue encompasses: underlying scientific principles and processes, technological creation and artifacts, historical development (of a concept or a technology), social or philosophical considerations.
(including conceptual transformations or even revolutions), and issues in other areas of human creation (e.g., music, literature, art) which are relevant to the main topic.

The Learning Environment: Museums and Virtual Sites.

Museums are institutions which accumulate and preserve knowledge in order to convey it to the public. A traditional point of view to museums claims that its main function is to preserve knowledge, therefore displaying original exhibits which are selected by specialists. The visitor's activity is to look at objects, to read or to hear explanations. Today it is quite common to look at museums as educational sites [Ingle, 1990; Vallance 1995]. A main issue concerning the learning process in a museum is what should visitors do except looking at objects. A way to handle this question evolved by developing a visitor-centered approach [Dor, Chen & Goren, 1988]. This approach is based on the fact that visitors come by choice, and chooses to act in the museum according to their needs. By wandering around, looking here and there, the visitor builds his private curriculum. Consequently, efforts are dedicated to develop workshops for children, to design exhibitions which are linked to the school curriculum and, what is more important regarding science and technology museums, to let people activate the exhibits. There is a tendency to turn museums into parks (e.g., La Villete in Paris), thus strengthening the bonds between knowledge and the way we spend our free time, and coloring the learning process with leisure and entertainment qualities. But if we examine the learning process which occurs while visiting science museums or parks some limitations become visible. Visiting a museum is not a regular activity for most students. It happens once in a while and it lasts only for a few hours. There is never enough time to examine the exhibits deeply or to get a full picture of a scientific or technological phenomenon. In order to acquaint yourself with the scientific ideas more visits are needed. Some museums maintain regular work groups, but most of the groups' members live near the museum and have the conditions or the motivation to come regularly. There is no question about the importance of the a museum as a learning site. The question is how we enable students to wander around whenever they wish, being free from time and place consideration, while maintaining relevant qualities of museums: activity, entertainment and social interaction.

A recent trend in computers technology, namely developments in virtual reality and their implementation in the information super highway [Mitchell, 1995], offers the opportunity to deal with these questions. We find on the Internet many sites which carry the name of virtual museums. The virtuality of these sites is based on the concept of "going inside" a place which has no physical boundaries, exists as bits and bytes, and within which many people may wander around. Every day we find more new museums and updated versions of old ones. More graphical features, nicer designs (fonts, colors, symbols, icons etc.) and more information items. But are these sites really virtual reality sites? Examination of the literature dealing with virtual reality indicates that the participant's immersion in the environment is crucial [Reingold, 1991, Heim, 1993]. The immersion feeling in virtual reality applications is based primarily on visual and audio stimuli, and on giving the user an active role to play. These are not (most times) strong features of existing virtual museums in the Internet. Though they use visual and audio items, there are mostly 2D stills, and their appearance on the screen takes to much time to allow immersion effect. Moreover, interaction or role playing is commonly not involved (we should not confuse between muse Multi User Simulated Environments- applications and museums).

The Virtual Knowledge Park represents an attempt to build a learning environment combining museums' functional and educational principles, virtual reality features and communication technologies features [Harasim 1993; Oren 1995; Pea 1994]. The Park comprises a number of spaces characterized by function, e.g., exhibition rooms (where 3D objects can be viewed, manipulated and activated); activity rooms (where on-line cooperative and interactive activities take place); knowledge center (an hypertext-like storage space for textual, visual and audio information); a public lobby and (obviously) the museum shop (where varied materials can be "obtained" -downloaded). A visitor may act in the museum in a variety of forms, ranging from simply watching or activating exhibits, up to complex cooperative on-line tasks (see [The First Working Prototype of The Virtual Knowledge Park]).
Learning processes

Our rational for learning within the Park focuses on two main levels: the knowledge, skills, and processes to be acquired, and the learning process while interacting with others.

The park offers a great amount of factual knowledge on different content areas. But besides fostering the cognizance of this knowledge, main learning skills and processes we intend to support are the student’s own construction of knowledge and the acquisition and application of varied sets of skills: scientific experimentation skills, technological design and problem solving skills, and information manipulation skills (e.g., retrieval, browsing, decomposition or recomposition). In addition, key goals are to support collaborative learning and creation of knowledge, and meaningful interactions among students working from distant locations.

Technological Features

Technological features of the park were defined vis-a-vis to their cognitive and learning significance. The environment is conceived as a virtual site in the internet. It exists as bits and bytes in Cyberspace by its own, and not as a web representative of a physical-world site. This means that an effort was made to define it as electronic reality, holding features, properties and rules which are substantive to that reality (and do not try to imitate by force other physical realities). Through the development process we have to deal with several substantial technology related questions, e.g.: -finding an appropriate compromise between the desire to design a sophisticated 3D environment and the demands (e.g., reasonable response time) resulting from on-line simultaneous work of several students from distant locations; -creating solutions for the interactions of (visually represented) personas present at a given time in the same location; -integrating varied action modes within the environment (e.g., wandering thorough 3D space, manipulating objects, or browsing html pages and vrm views); -integrating textual, audio and video communication among visitors to the Park.

While designing the Virtual Park the following issues were taken into consideration:

The creation of a VR-like environment: The user interface of the museum enables the user to walk through a three dimensional virtual environment and interact with exhibits and other users. At this stage we have decided to adopt only partially the features which characterize virtual reality systems. We have not adopted the commonly used input/output hardware accessories, e.g., head-mounted displays. Two reasons support this decision. The first, and more mundane, are the limitations it could impose on potential users at schools, homes, or other sites (e.g., costs, computing facilities, maintenance). But the more important reason is the still poor state of research knowledge regarding the educational and psychological implications of the use of the nascent VR technology.

Although running the museum at this stage demands high-performance-graphics hardware, the cost of such technology is even today much less than HMDs, Booms or Caves. We believe that appropriate graphics capabilities will be common in the near future in school or home PC’s, and we have already began working on a version of the museum’s interface software for these platforms.

Distributed Approach: The Park is a distributed environment. Both the Park’s interior, it's exhibits and user actions (such as movements, communications etc.) are distributed among the different systems on the museum's net. There is no central server for handling all the communications. Once a user enters the Park all the other users are immediately aware of his/her actions.

Changes in the Park exhibits are also broadcasted to all of the museum users. It is possible to either distribute the exhibits themselves, or links to exhibits which reside on other machines (very much like how the WWW works).

Evolutionary Development: The Virtual Park is undergoing an evolutionary development. Both the demands from the museum and the technology are rapidly changing. The Park’s design emphasizes flexible design that enables both fast prototyping and reusability. Object Oriented Design procedures are used to create
and encapsulate several modules. The models could be extended or replaced during the different stages of the development.

The First Working Prototype of The Virtual Knowledge Park

For the first prototype of the Virtual Park we have developed a set of spaces (a wing) focusing on the scientific, technological and cultural aspects of Galilei’s works, e.g., his scientific contributions, the role of technology and instruments (e.g., telescope) in the development of theories, the controversy with the church and Aristotelian concepts. The wing is called “ANDREA’S Wing”, the scientist’s loyal student in the Bertold Brecht’s version of the Galilei's drama. Andrea the student in the play represents the opportunity to access not only the master’s science, but also the teaching interactions among the two, and finally, the human and cultural significance of the conflictive confrontation between opposed conceptions and ideas (as those sustained by Galilei and by the Church).

The park was conceived as a modular assemblage, being the wing its basic building block. There are five types of functional spaces in the Park. Two general areas are accessible from all wings: the Main Lobby and the Knowledge Center. Three more areas are defined locally for each wing: exhibition areas, exploration areas, and workshop.

General areas: In the main lobby assistance and information is supplied to the visitors, in the form of navigation aids (e.g., a 3D map of the Park, or a set of visual menus), and information boards (e.g., about general public activities, schedule for the week, or new exhibits). As in real-world museums and centers, the Park’s Shop is also located in the main lobby. This is the place where students can “acquire” different kinds of souvenirs and materials. The shop offers the possibility of downloading written, audio and visual materials (e.g., a map, a song, a short animation), learning activities (e.g., a puzzle, an experiment kit), or a souvenir (e.g., a poster related to a current exhibit, signs for the room’s or class door).

The Knowledge Center is an hyper-like electronic information web. A large amount of information pages is interlinked, as well as linked to many different relevant locations in the world web. The information contained is of various kids: text, sound 2-D, and 3-D (VRML) stills and animation. Access to the center is allowed from everywhere in the Park, by means of an interface feature represented as a (virtual) device called “the percolator”. If the user is located in a particular wing, using the “percolator” allows immediate “teleporting” to the Knowledge Center at a specific entry point, in correspondence to the wing’s main topic (instead of the Center’s top level menu as if it is accessed from the Park’s lobby). A specific subsection of the knowledge center is the Education Services Center. It contains learning materials for teachers and students aiming at specific goals, (e.g., focus on a particular topic or set of skills), or type of activity (e.g., a guided tour, a treasure hunt) or curricular connections with regular school activities.

Wing areas: At the exhibition rooms the visitor can find, learn about, and manipulate 3-D exhibits. For example, in the Andrea’s wing exhibition room the student can find exhibits like Galilei's telescopes, pendulum, heliocentric models of the solar system, or books like Galilei's writings, the Bible, or Aristotelian writings (Figure 1). The objects can be inspected and manipulated, and “opening” a book means entering the section of the knowledge center where the texts and related information are stored. At the exploration rooms scientific or technological experiences can be performed. For example, students can replicate Galilei's inclined plane experiments, but in a different setting and in collaborative ways. In this case the environment is a virtual playground, with slides (inclined plane) and swings (pendulum). Different students present in the same space at the same time can (virtually) slide each on a different slide (with different lengths and angles), measuring sliding time and distance. Each student can see each others sliding, a board showing all results. The students can now analyze and interpret the results, and elaborate on their implications (e.g., regularities, hypotheses, predictions).
At the workshop the students meet for performing fairly complex collaborative learning activities. In our exemplar wing the planned activity is a role playing event centered on Galilee's trial or investigation by the Inquisition. Students have to sign in two weeks in advance, choosing one of the ten characters participating in the event (e.g., Galileo, the Pope, the Inquisitor, Aristotle, Einstein). Each character has to prepare her or his presentation at the trial, using materials and documents contained in the Knowledge Center of the Park (Figure 2). A week before the trial, all presentations are delivered to all participants (via the network), for considering their responses. The day of the trial all participants meet in the (virtual) workshop room, and the trial proceeds as an audio (and if possible video) conference. Each participant gets a slot of time to deliver her or his presentation, followed by a discussion, and then verdict (here is the place for the “public” -other people connected and present in the trial- to participate and vote). One of the characters is the moderator of the discussion, being her/his main role to maintain the trial’s rules and proceeding from stage to stage.

Figure 1: view of Galilee's room
Concluding Remarks

The Virtual Knowledge Park project represents an attempt to explore new educational applications of computer-communication technology. The search for these potential applications was primarily guided by learning and cognitive considerations: we did not want to merely install the new technology in schools only because it is here, but to relate it to substantial learning needs and questions. This led us to the building of the rationale of the project as an integration of theoretical approaches to learning (e.g., development of alternative learning settings, guided discovery, information manipulation processes, collaborative learning) with features of the new technologies (e.g., virtual spaces, multi-user communication activities, integration of different media, hypertext, the world web). Through the definition process of every component of the Park a basic question stud always in the background: how it relates to our rationale and to our basic educational questions.
Our research and development agenda takes us from now on in several directions. The first is the transition from a lab prototype to a fully accessible site. A feature we are already incorporating for supporting this goal is the development of multilingual (Hebrew, English, Arabic) versions of portions of the Park’s information. In addition our goal for the next stage is to develop support for different hardware platforms in use at schools.

Another direction relates to the completion of the basic model for a wing (structure, modes of interaction, repertoire of learning activities), to be used as a template for further building of new wings by developers at our center and in schools.

Finally, we will devote considerable effort in studying substantial questions regarding the students’ work and learning within the Park, e.g., motivation, interaction with the environment and among students working at distant locations, acquisition of unique skills (e.g., browsing in the knowledge center, exploration of virtual objects), trigger for further learning, or transfer.

References


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Israel, for their support. Their assistance in hardware, software and technical advice is a valuable contribution to the advancement of the project.
Abstract: Strategic farm investment analysis is a meld of objectives, budget data, time horizons, selection criteria, etc.; a complex integration task even for formally trained practitioners. Isolated farming families have many “strategic problems” that require appropriate analysis. But, often, they lack the knowledge, understanding and access to procedures, data and advice considered necessary for developing solutions appropriate to their business. This paper addresses some of the issues encountered in a CAL project designed to provide some solutions: issues about distance learning, the inclusion of appropriate calculation aids and taxation advice but, above all, the need for sensitivity to social implications and interactions within farm families.

Motivation and Opportunities

The general focus of the project reported in this paper is on strategic farm investment decisions; the specific task is to design CAL software that will help decision makers both better understand and carry out this important function. The approach to this basic material is largely prescriptive and is essentially based on team members’ experience. There is, however, a measure of practical enquiry (involving potential end users) built into the CAL development; this enquiry process has served, and will continue to serve, as a moderator and improver of approaches.

Strategic Decisions

Strategic decisions are those that have long term impact on farm business viability and also those that have longer term environmental consequences. Some business examples include additional land purchase, major capital item purchase (especially large machinery items), development of alternative crops, establishing an intensive animal enterprise. Environmental examples would be property planning investments involving tree planting for wind, water, salinity or erosion control. The distinction between “business” and “environmental” investments is made to highlight the different attitudes to investment selection criteria that might exist among farmers.
Importance of the Project Topic

Most strategic investments involve large (relative to business size) capital outlays which usually have to be funded from debt rather than equity capital. While the financial implications of borrowing are always serious for a business, they are exacerbated during natural disasters. Frequently, however, it is not the natural disaster which leads directly to failure but inappropriate borrowing for expansion of property size, overcapitalisation in machinery and an associated lack of understanding of basic taxation principles that affect these major strategic decisions.

Accompanying these problems, it seems there is some lack of understanding by farmers of how to integrate such decisions into the total framework of the farming business i.e. to ensure that the investments are financially feasible and can be continually monitored. It is also reasonable to speculate that lack of involvement of the ‘whole’ family in the strategic investment process often results in the consequences of poor decisions being visited not only on the husbands but also on wives and children along with the general community.

Funding support for this project was achieved because of its focus on remote and distant learners and the possible benefits to the community in reducing the social and financial trauma associated with total business failures. The chance of lessening the need for periodic and costly special government aid to “bail out” victims of natural disasters also played a part.

Project Objectives

Initial objectives were:

- to develop Computer Assisted Learning (CAL) software that will provide farmers with an understanding of, and methods to approach, strategic investment decision making;
- to ensure that this would be done in the context of their own business (own problems / own data) and with assistance on appropriate taxation issues;
- to utilise available distance learning infrastructure and personnel in making material available to farmers in remote areas;
- to involve farmers in the specification process and provide a learning environment in which the whole farm management team can become involved.

The project’s first focus group exercise with farmers (see Social Issues in Investment Analysis) highlighted the need to reorganise and rethink project priorities to ensure that there was an emphasis on the social dimensions involved in each stage of the decision making process. This re-focusing also caused us to re-evaluate the various “tools” we had intended including in the software and the nature of the help that was needed to facilitate learning and effective support for the investment task.

Practical outcomes which influenced the project emphasis were: a re-appraisal of the more complex calculations to devise simpler methods requiring less data; inclusion of more examples; enabling users to “drill down” as they require more information; inclusion of more extensive help facilities including “walk throughs” by a range of consultants (though no expert system components are currently included) and a move towards a true multimedia product (inclusion of video, sound) to be output in CD ROM format.

Issues

The processes involved in making farm investment decisions are varied and complex in nature. In attempting to provide a high quality interactive CAL learning environment a number of key issues arose during the design of the project. The issues varied from such things as learning support environment, the nature of the social interaction involved in the decision making process, the nature of the delivery environment, the types of investment calculation tools to be provided, the software development environment and the overall project management approach. During the evaluation of the project it is hoped that answers to the myriad issues and questions, direct and implied, will be provided. Below we discuss a few of the issues that have surfaced to date.
Social Issues In Investment Analysis

Typical stages in an investment analysis process involve establishing the business and personnel resources, defining the investment, calculating profitability according to accepted criteria, assessing financing and risk feasibilities and developing an implementation and control plan. The initial view of project team members was that the calculation and financing aspects would be the main focus in our project.

One of the first tasks in the project was to gauge farmer opinions about the land purchase decision and obtain their reaction to the type of material we were expecting to develop. A facilitated focus group of eight farmers met over a 2 day period. The group was very positive about the concept of the project as a whole and in their discussions emphasised the issue of human (family and non-family) social interaction when dealing with land decisions. From the information provided by the focus group, issues of social interaction were treated as being at least as important as the budgeting and financial calculation issues. In the overall design and development of the project not only have social issues have been promoted in importance but we have allocated more project resources to additional focus group work as each investment topic is developed.

Content Issues

Among the project team one debate has been whether we can adequately address the development of calculation models and tutorial material within the same application. There is little doubt that the concepts involved in the calculations are moderately complex for some, if not most, farmers. Concepts of “time value of money”, the effects of inflation, discounting cash flows and establishing a cost of capital, profitability versus financing (Boehlje and Eidman, 1983) are difficult for many. Is there value in trying to help people understand these concepts when all they may really want is a means of getting to the answers? Alternatively, if the object is to help people learn principles, do we need to include “real data” calculating tools. Perhaps farmers will be content to leave these more difficult aspects to advisers and consultants? Our conclusion was that it is important for remote learners to be able to mix their learning of principles with their ability to perform investment calculations. It was felt that only by using their own data within their existing business structure and taxation situation and using their real options as opposed to examples, would farmers be likely to engage fully in the individual and team learning processes involved. Also, we have tried to design the software in such a way that users can choose the depth at which they immerse themselves in the whole learning / calculating process.

Learning Issues

The essential aspects of teaching-learning, as outlined in the Laurillard model of learning (see Laurillard, 1994), are discussion, interaction, adaptation and reflection. The student is presented with a concept from the teacher’s point of view in the initial discussion, this concept is refined and altered through interaction between student and teacher, other students and the real world; the student’s understanding of the concept undergoes adaptation and change because of the interaction and finally there is reflection on this new understanding of the concept. Within a classroom or lecture setting, it may be difficult if not impossible to ensure this approach is followed and that all aspects of the Laurillard learning model are encompassed. The nature of the learning environment provided on a farm means that our intended audience (isolated, adult, busy, lacking in formal education, mixed gender, etc) have enormous opportunities for discussion and reflection. Opportunities exist for participants to work collaboratively in developing a group understanding of the concepts at hand by working together on their real life problems. It is felt by the project team that the uniqueness of the farm learning environment adds greatly to the learning process and will be a great motivating influence. How these perceived learning advantages are handled by the software design will determine to a large extent the success of the project.

There are many distinctive features of self-instructional material (Lockwood,1995). Three of these, active learning, private learning and individualised tutoring, seem to have special significance for the work addressed in this project. Active learning: The areas of problem identification and definition, essential steps in the investment analysis process are seen to be fairly complex for inexperienced learners, but less difficult for more experienced persons working on their own problems. "Active learning", as Repman et al (Repman, Price, Logan 1995) point out “provides students with an opportunity to identify and solve real problems”. To promote this active learning environment for novice users substantial use is made of exemplar case studies. This not only provides ‘real’ data it also establishes a framework within which users can construct their own problem space.

Private learning: For people who have not had, or taken, opportunities of formal study, it is often difficult to face the prospect of public demonstration of their abilities. Farmers are probably a classic group in this
regard. Remote self-instructional learning provides opportunities for building self confidence by allowing mistakes without public exposure. Unlike the approach one might take with undergraduate students who often need the motivation of external assessment to reach the goal, remote adult learners are more likely to need help in striving for a “deeper” analysis rather than meeting external assessment targets.

Individualised tutoring: The facilities provided by the telecommunications environment and distance learning centres (see Remote Learning System) mean that tutors can respond to learner’s needs in a timely and personal manner. In addition, the support infrastructure can also act as an information and help resource for both the learning material and also the hardware and software being used by the farmers. In this environment it is hoped that the real problems of individuals can become the focus rather than contrived situations often presented in formal classes and courseware.

**Distance Learning Issues**

Developments in telecommunications infrastructure and the availability of an appropriate support environment in Western Australia, provides an opportunity to trial distance learning materials for farmers and their families as part of the project. The project goals included the distribution, support and evaluation of the Cal-farm learning materials direct to farmers (mailed disks) in very remote sites. Additional support for the distance learning component of the project was also available from the personnel at the Remote Learning System at the C.Y.O’Connor College in Northam, Western Australia. This group have had a number of years of experience providing both support and learning modules to farmers via modem facilities.

Currently there are 400 active farmer learners on the Remote Learning System and this seems to provide a reasonable base for initial dissemination, testing and feedback of the Cal-farm materials. Unpublished data from an informal survey of their clients indicates strong appreciation of the learning opportunities provided by the system; we may be dealing with a group favourably biased towards any form of learning made available to them.

**Design Issues**

The Model: What parameters do farmers consider when making strategic finance decisions? How do the farmers weight these parameters? What strategies do farmers use in weighing up risk? Do farmers use different strategies for assessing different financial investment problems? These are just a few of the questions which the project group posed during their problem definition phase. Some of these questions will be more formally explored in later focus group work; this will help underpin or modify the prescriptive approaches taken.

Using prototypes: A prototype decision analyser for making investment decisions about farm machinery investment was developed and evaluated in the Remote Learning System. It led to substantial changes in our approach to metaphor implementation and screen design. This experience taught us the importance of cyclical evaluation rather than wait to test completed products.

A mathematical model which simulates the complete farm investment environment was also developed using a series of spreadsheet models. These will provide the underlying calculations but in such a way that users will be able to choose the depth of interaction they desire and not be overwhelmed by excessive data requirements; we may have to accept some trade-off in accuracy at the “simpler” levels.

**Hardware and Software Issues**

As Feldman (1994) reminds us, multimedia (and plain CAL presumably) is not solely a technological issue: “It is people who design multimedia systems and it is people who use them”. In the case of remote users, however, we not only have less control over the technology available but we are unsure of the “base” system to aim at and of users’ technology upgrade plans. Will they have upgraded by the time our product is ready? Will the authoring system allow free runtime distribution, etc. The end result of these deliberations is nearly always a compromise on the ideal environment.

We chose the IBM PC platform because our experience and commercial contacts indicated that the bulk of potential users are in that market. Also, in order to deliver material through the Remote Learning System discussed above, participants need access to an IBM PC or compatible computer. A 1992/93 survey in New Zealand (Nuthall and Bishop-Hurley, 1995) indicated 19% of farmers used computers commercially. Anecdotal evidence suggests that the
usage rate in Western Australia is much higher than this but, even if it is not, access to the technology should not be an inhibiting influence on the success of the project.

The design level was aimed at a Windows 3, 486-level CPU machine with standard VGA, and common hard disk capacity (150 MB). It was recognised that most of the initial audience (see Remote Learning System) would have access to a modem. We thought that it would be useful to create modules which would each occupy about one megabyte in compressed form, that is, we wanted, at least at the outset, to keep components within the scope of a single floppy diskette. Modules of this size can be downloaded over a 9600 bps link in about 20 minutes, and can easily be mailed out in a standard letter-size envelope.

The choice of authoring systems engendered a lively debate, and came down to a contest between Microsoft’s Visual Basic and Asymmetrix ToolBook. Proponents of the former had a solid case when we considered module size; Visual Basic produces relatively compact run-time systems (Nelson, 1994). However, ToolBook is more easily applied to the development of interactive CAL material, and we had many more ToolBook resources available to us than was the case for Visual Basic. Borland’s Delphi, however, is a likely contender for intensive calculation and mathematical graphics. HDK (see Help Facilities) is being used to develop help files.

Help Facilities: Rather than provide large quantities of embedded text-based information, a glossary of tax and finance material has been developed in parallel. The key issue here was whether to use the Windows Help environment as the delivery mechanism or include the material within the project itself. The project team considered that it was educationally better to limit screen text and only make ‘text-based explanations’ available as a reference tool when required. Using this approach meant that the Help System could be used as a stand alone teaching resource for other teaching purposes. The limitation on space for disk-based products also meant limiting the amount of graphic work in the help files themselves.

The choice of an authoring system for the development of on-line hypertext-based help files, i.e., Windows HLP files, was comparatively easy. One can either author such systems from scratch, using a stand-alone development tool such as the “Help Magician”, or one can use Microsoft Word to create base documents, and then transform these to HLP files using a compiler such as that found in the Australian-made “HDK” (hypertext development kit) system. The stand-alone systems are more intuitive to use, and much faster to compile, but we knew we would be working with numerous Word documents as our source material, and hence opted for application of the HDK system. HDK was one of the first Windows 3 help compilers capable of producing the volume-book-page hypertext metaphor now commonly seen in Windows 95, and this was another factor in its favour.

Did we consider setting up CAL and HLP modules for access via the World Wide Web? When we began our planning, access to the Web from Western Australian farms was essentially nonexistent. Now that a number of Internet service providers have sprung up, we may eventually make material available for downloading over the Web. Web downloads are usually less expensive than bulletin-board system (BBS) downloads. In actuality, however, Web traffic in Western Australia has grown faster than has the bandwidth needed to support it, and what might be a 20-minute download from a BBS can at present take two or three times longer over the Web. We are keeping our options open on this issue.

Conclusion

Overall, it would appear that the area chosen for this implementation is reasonably complex in terms of the sorts of learning issues that need to be addressed. These are associated with the teaching-learning process itself and aspects of remote self-instructional learning. However, there are some very positive aspects to learning remotely via multimedia. One aspect is the possibility of collaborative learning which we are trying to encourage by the design of our software. Our ultimate intent is to facilitate the ideas of the “learning organisation” as portrayed by Senge (1992) especially with respect to shared vision and team learning.

References


The Technology Rich Classroom Project: Where Learning Soars

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Abstract: The Technology Rich Classroom (TRC) Project integrates computers used as a tool for learning with other strategies to meet the needs of all learners. A central feature of TRC classrooms are their multimedia computers integrated into regular teaching and learning activities. Technology-based projects engage and interest students, motivating them to commit to learning. The projects provide for connections between the disciplines of knowledge and to the students' lives. Students develop skills for problem solving, creativity, collaboration, life-long learning, and using technology through class projects. The project structure provides for individualized learning, varied time for instruction, and differentiated curriculum for all students. Technology allows students to work in and combine various media including sound, still graphics, motion video, and text. TRC teachers are exploring learning stations, cooperative learning, learning theories, interdisciplinary curriculum, project-based learning, and authentic assessment.

Introduction

It was a cool April morning, the Monday after the twenty-fifth anniversary of Earth Day, and more than 200 elementary students were excitedly moving from activity to activity at Lake George Regional Park. Students used empty plastic soda bottles to make planters, terrariums, and bird feeders. Other students played the games in the new environmental education building. Some were studying water from Lake George under a microscope. Still others were touring the new nature trail. The most exciting aspect of the day was that our 50 fifth and sixth graders designed all the activities, including the new nature trail and environmental education building. These students became involved with active learning through the Technology Rich Classroom Project.

Maine School Administrative District #54's Technology Rich Classroom (TRC) Project is where we hope to create our vision for education. That vision is to make M.S.A.D. #54 a place where all students are actively learning and constructing their own knowledge, where educators apply research on learning and are themselves learners, where a developmentally appropriate education is provided for students, and where assessment strategies accurately detail what each student knows and can do. Over the last few years, we have seen the TRC project become a powerful catalyst for changes in teaching, learning, technology use, and teacher support and inservice.

One TRC Teacher's Story

JoLynne Crout's Fifth and Sixth Grade classroom in Canaan Elementary School became part of the TRC project in the fall of 1994. Canaan Elementary School, a K-6 school with 14 teachers, serves approximately 240 students. Canaan is rural, even for our district, and is largely composed of blue collar families who work in the woods or at local mills and factories. Here is JoLynne's story of being in the Technology Rich Classroom Project:

It started with mukluks. I was involved with dog sledding and had just recently attended a meeting of interested mushers where I found a mukluks catalog which included a centerfold about the International Arctic Project. It mentioned that there would be a team of six expeditionaries. What made me really enthusiastic about this is that it included two women. As a teacher, I admire women who go beyond the normal boundaries. It said that they were going to take a 2000 mile trek across the Arctic using canoe sleds and skis. One of my goals was to go on a trek across the USA, but this was more exciting!

The International Arctic Project had an environmental classroom component offered by World School. I called for the
advertised teacher packet. When I received the materials, I discovered that my kids could be involved in the project if they could get onto Internet. The project would include communicating with the expeditionaries and other students from around the US. Because of our isolated area, I felt it was important for my students to get exposure to other cultures and communities.

That fall, I had been chosen to be part of the district's Technology Rich Classroom Project. We received a printer and two brand new Mac LC 550s with CD-ROM drives, but very little software. I participated in a two day orientation right before school started and as soon as we got the new equipment, we tore open the boxes and punted! All I had before were two outdated Apple IIe computers, which still break down when the wind blows. I wasn't really sure how to use our new computers, but knew that my kids could help. Andy, one of my students who had a Mac at home, became my first computer expert and offered to help. One of his first actions was to give me the manual and tell me quite firmly that I had a month to learn everything in it! Whenever the class tried something new that we could not figure out how to do, we'd call Andy to come and show us.

I had to learn from working on my own computer at home, which was mostly used by my 16 year old daughter. The computers at school were used by students the whole day and I couldn't get on them until long after school. I decided we needed to train kids to train other kids. Andy trained the first group, and slowly we learned how to use the few programs and CDs we did have.

Later in the fall, I was able to sign up for a Technology Rich Classroom course. One of the instructors was the Middle School's Computer Resource Specialist, Mike Muir. The course gave us an opportunity to play around with the software, to see how group dynamics worked, and how I could apply it back to my classroom. It showed me that two computers could be used by six people working cooperatively on a project. The course presented a project-based model for curriculum development, including the use of learning centers.

I had tried centers the year before and it had bombed! I tried to put my finger on the cause and what I discovered was that it was the technology that was missing. Using the computers provided an extension to students' knowledge. Just being able to access information on the Grolier's Encyclopedia CD opened up whole new possibilities. Learning centers had been really hard to do because the information just wasn't there and students didn't want to take the time to look it up, or it was old and outdated information. Being in an isolated area, it was difficult locating resources. I had spent thousands of dollars of my own money to buy books so kids would have good resources for their projects, but the technology provided up to date information which could be located quickly. Students could see it, they could access it, they could find it on the computer in a way which would make it real to them. On the computer, they were in control of their own learning.

The format of the TRC course allowed for individual preference for what we wanted to learn. If we wanted to spend 6 weeks surveying software, we could do that. If we wanted to preview CDs, we could do that. There were also minilessons for interested teachers to learn about other equipment, like the scanner, the modem, and the QuickTake camera. Becoming aware of what was available was helpful because then I knew what to request in a budget, or from the district coordinator for preview. The instructors asked the participating teachers what minilessons they wanted and involved the teachers in decision making about format and objectives for the course. That meant that we were free to learn what we wanted to learn. Because I could focus on what I was most interested in, it was the easiest class I had taken and the most fun!

From the format of the course, my own style of teaching evolved. Everything I learned in that class I took back to my own classroom, because I had seen that others had tried it and it worked. I adapted it to my own style and fine tuned things I already did. Between things I had already done in my class and what I learned in the TRC course, I knew I could do learning centers, design projects which addressed our curriculum, and give students choices about how they would learn. I decided to tackle these ideas through the International Arctic Project.

Dave Person, the district computer coordinator, provided the subscription fee to become part of the project. That told me that he trusted my ability to carry it out. He also promised to have a phone line installed so that we could get onto Internet. We waited many weeks to get the phone line and when it was finally installed, the administration placed a long distance block on the line. There is no local access to Internet in Canaan, so even though we had the phone line, we could not carry out that part of the project in the classroom.

The International Arctic Project has three components. Students could follow the Arctic expeditionaries through their daily reports posted on Internet. Using the net, students could also ask questions of the expeditionaries about their trip and the research they were conducting on pollution levels in the Arctic. The second component was conducting a local
environmental education project. This could be classwork or a larger, community-based project. The third component was being connected through the Internet to other educators who were part of the project. There were four other schools participating and we shared ideas and the results of our local projects. Through St. Thomas University in Minnesota, who was coordinating World School's International Arctic Project, we had access to graduate students who helped design related classroom lessons and activities, and also to experts on the Arctic who could help answer students' questions.

This required a great deal of telecommunicating. The computer coordinator tried to find ways that he could provide local or inexpensive Internet access, but none of the options worked out. Mike Muir, who provided TRC classroom support in the afternoons after the Middle School let out, tried what he could to get our classroom computers connected, but to no avail. I was stuck with doing my telecommunicating from my home computer. The enthusiasm the project generated in my students more than made up for my long-distance phone bills.

Students and I brainstormed environmental activities, then spoke with officials at our nearby regional park, finally deciding on several projects: an environmental education building and nature trail at the park, planting flowers and trees at the park and school, a vegetable garden, and recycling and composting endeavors at the school. My students developed their plans, then presented them to the Board of Directors of Lake George Regional Park. The board became enthusiastic and eagerly supported our ideas. Students, divided into subcommittees, dove excitedly into the projects. When someone entered our classroom, they might have thought it was chaotic, but it was not. If they had spent time there, they would have seen it was meticulously organized and that students were thoroughly engaged.

Part of the challenge to teachers is creating environments which are rich enough in resources that students can take from it what they are most interested in. Having lots of resources does not have to mean lots of money. We used tool software flexible enough to meet many working and learning styles, books borrowed from libraries around the state, and supplies consisting mostly of recycled materials. Technology extended our resources. Ten year old conventional encyclopedias in our school are outdated. CD-ROM encyclopedias and Time Yearbook discs provide the latest information. Internet gave students access to new research that was literally hours old.

Some of the individual environmental projects were truly amazing. Billy and Sally created an oil spill simulation and dipped various "animals" in the spill to show what effect it would have. Donna compared various states' pollution levels to Maine's. Ralph and Susan created an oil spill in a bucket and tested the effectiveness of various materials on absorbing the spill. Students created a rain forest complete with (nearly) full sized trees, plants, and animals. One of the most interesting projects was constructed by Nate and his family. He created an erosion simulation by building a slanted table, filled with sand, and connected to a fish tank which pumped water down the slope.

On the Monday after Earth Day, packed with my student's individual projects, we opened our new Environmental Education Building at Lake George State Park.

The Technology Rich Classroom Project

M.S.A.D. #54 serves approximately 3300 students in Skowhegan, Canaan, Cornville, Norridgewock, Mercer, and Smithfield; towns in rural western Maine. Computer equipment in our 8 elementary schools is centered in our TRC classrooms. There, through project-based assignments, small groups of students are assured several computer experiences each day as they move around the classroom to diverse computer and learning stations to research, organize, interpret, and present information. These classrooms provide a significant increase in resources over traditional classrooms and create an instructional setting where knowledge and "doing" are powerfully linked. There are currently 31 Technology Rich Classrooms, approximately 37% of all K-6 classes. Every school and every grade level has at least two classrooms part of the TRC project.

The TRC Project began during the winter of 1993 in four classrooms as a pilot project funded by Chapter II. At the end of that year, the project was evaluated by Chapter II, receiving favorable reviews. In the fall of 1993, 10 TRC classrooms were added, providing representation at every grade level (K-6) and every elementary school in the district. In the 94/95 school year, the district funded 17 additional TRC classrooms. We are learning that technology can serve as a critically important resource for creating powerful, meaningful, and authentic contexts for learning.

The vision for TRC classrooms provides a learning environment which meets the learning needs of all students. Technology-based projects engage and interest students, motivating them to commit to learning. The projects provide for connections between the disciplines of knowledge and to the students' lives. Students develop skills for problem solving, creativity, collaboration, life-long learning, and using technology through class projects. The project structure
provides for individualized learning, varied time for instruction, and differentiated curriculum for all students. Technology allows students to work in and combine various media including sound, still graphics, motion video, and text.

Technologies vary according to school and grade level, but each TRC classroom has a printer and two to four color Macintosh computers, at least one equipped with a CD-ROM drive. The approved district goal is to reach a student/computer ratio of 4:1. Although well short of that goal, our current K-8 student/computer ratio is 11:1. The district has additional peripherals, including a laser disc player, color scanners, two digital cameras, and a video digitizing station, which are shared among the schools. Some classrooms have phone lines for telecommunications, but, as stated earlier, the district maintains a long-distance block on those lines. (Toll-free telecommunications access in our area is extremely limited.)

How TRC Is Impacting Students

A major infusion of divergent technologies into a classroom offers an opportunity to rethink traditional practice, and can lead to changes in teaching and learning. In the more successful TRC classrooms, we have seen the following shifts:

* from whole class instruction to small group instruction
* from lecture and recitation to coaching
* from only a few students getting attention to all students getting attention
* from passive students to engaged students
* from assessment based on test performance to assessment based on products, progress, and effort
* from a competitive structure to a cooperative, social structure
* from students all learning the same things, to learning different things
* from verbal thinking to the integration of visual and verbal thinking.

Some of the teachers in this project have been very successful in meeting the diverse needs of students. The TRC project's greatest impact seems to be on students with learning differences because of the visual nature of working with the computer. QuickTime movies and recorded speeches brought learning to life for many students. Seeing unfamiliar animals move on the screen or hearing Martin Luther King, Jr., give a speech makes them more real to students. Further, computers provide visual cues to students who are nonreaders, allowing them an avenue to success. The computer also allows students to work in visual media and we have seen reading come slowly to students who learn first to express themselves in another medium. Further, we have often seen a role reversal between what have traditionally been successful and unsuccessful students. Many of our "non-academic" students show successes creatively or through visual media, skills many of our "academic" students seem to have difficulty with. These two groups of students, who normally do not talk with each other, end up forming a friendly and productive alliance, sharing knowledge and skills.

The technology has also proved itself a self-esteem builder because there is no failure. A computer is a piece of equipment that does not tell students what to do, they tell it what to do; they are in control. Computer-based resources also put students in control of what they are learning and tool software, such as Kid Pix, HyperCard, and ClarisWorks, place students in control of how they share that information with others.

The project-based approach and rich collection of computer and non-technology resources allows for diverse students to work successfully. Our experience is that it is very difficult to keep everyone at the same level of learning for consistent whole group instruction, but having numerous varied activities allows everyone to work at his or her own level and in his or her own learning style. It also frees us to work individually with students. We have found that when students are at learning stations, learning what they want to learn, they take off and fly! In fact, most students's projects and presentations, seemingly regardless of student ability level, are of the same high quality. During a recent Jigsaw activity, it was impossible to tell who were the special needs students and who were not. When our class presented their ideas to the Lake George Board of Directors, some of the best presentations came from students who have not traditionally been successful in the classroom. We have numerous examples of students finding new success through the TRC project:
* John, an unmotivated student, did an outstanding report on scorpions. While looking through Boys Life for information about hunting, he came across an article on scorpions, and fell in love with the topic. His attitude quickly changed from apathy to hard-worker as he dove into researching his topic and creating his report.

* Allison, who reads on a first grade level, can word process her own reports after someone reads her new information. Amazingly, she can read any information she types herself. She also learns the material well and has demonstrated her self-confidence as a teacher. Allison ran the environmental education building on our opening day.

* Lisa is a potential drop out student. She has shown a great deal of computer expertise and we groomed her to be one of our student computer experts. Since we started working with her, her attendance greatly improved. She even stayed in school the entire day, waiting for training in new computer skills during the last period.

There also seems to be fewer behavior problems in TRC classrooms. We believe that the rich learning environment and building on student interests are responsible for this shift. We teach the students conflict management skills and students must solve their own problems, with our guidance. Project work and learning stations free us to talk individually with students when the need arises. Even students who usually provide the most severe misbehavior can be redirected with a minimum of effort.

Feedback from parents has been phenomenal! It is because of their support and desire to have their children in the program that we have increased our technology budget in tight economic times. The community and school board supported our efforts with a 50% budget increase for hardware and software for 94/95. The presence of these technologies symbolizes change for students, parents, teachers, and the community. New technologies are one of the most visible and obvious manifestations of how the world has changed and how quickly it continues to change. It was only severe funding shortages for the 95/96 school year which forced a cutback in resources and put a halt (hopefully only temporarily) to expanding the project. Even so, there is enormous pressure on administrators as parents demand that their children be placed in TRC classrooms.

One of our favorite indicators of the educational and academic success of this project came from Lake George State Park's ranger. He commented that he never worked in groups as a student and, in fact, found teachers to be intimidating. "I'd love to be in your classroom," he said, "The atmosphere is more relaxed, but the expectations are higher and the work is more interesting."
An Interactive Hypermedia Tutorial for Power Electronics Instruction

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Abstract: One approach to instruction based on a constructionist view of learning is to provide rich environments in which learners can actually construct their own knowledge. Using Kolb’s pedagogic model, we have created an efficiently environment that can be explored by learners, in which they have tasks to perform, contextual access to knowledge displayed in a hypertext format and access to real experiences by simulation. Our learning aid system which was implemented using commercially available author’s systems consists of three main modules: Hypertext, Tutorial and Simulations, including help applications such as, calculation tool, animations and learners control.

System Overview

One of the most promising technological advances for education is the use of the educational multimedia technology. But only educational software carefully designed, can improve the efficiency of courseware. Our learning aid system have integrated the PSpice simulator with a knowledge-based instructional module, in order to achieve an important improvement, in the student’s knowledge of process design and analysis engineering, in Power Converters area. Simulation helps the expert users to understand the converters performance, and in other hand, the techniques multimedia employing, allows the novices integrated knowledge and concepts through the guided cases study, which they can gain information on the subject of Power Electronics. Furthermore, the students are provided by several utilities such as, a powerful calculation tool integrated that solves mathematics expressions, and assistants them in studying of the quantitative aspects of the power converters, such as: harmonic analysis, discontinuous conduction, rectify-inverter mode or improvement of the efficiency factors.

Pedagogic Model

Nowadays, our schools and universities are filled with a variety of information, coming at us form all directions. Our students receive (and may store) overwhelming amounts of information. So, they must choose to attend to some information while ignoring other information. Hence, we must to develop information-rich learning environments in which learners select information resources from which to learn. Using multimedia resources we may provide information in a variety of forms and enable students to their own path through the information. In the Interactive Hypermedia Tutorial, that we have implemented, the student plays a more active role in thinking about what knowledge is relevant to put in a case or what knowledge o what factors are
important in converters’ design. Thus, it will allow the learner to develop higher level learning skills, rather than simply become the passive recipient of new technology.

In contrast to the traditional approach to instruction, in which the students become “consumers of Knowledge” (in Brandford’s terms [Brandsford et al. 1991]) and the concepts are abstracted from their use in the real world, many theorists accept the Piagetian notion that learning is a constructive process [Vosniadou & Brewer 1987]. In this order, in our system for Power Electronics instruction, the student works through several guided cases moving back and forth between the questions and solving problems and he learns about concepts because of that he comes to see the multiple contexts in which a concept occurs in real contexts. Our Tutorial provides a case-based learning, in which the cases capture and represent the complexity of real experiences. The instruction is focused on learning and understanding for a concept and that understanding must arise through working with the concept in the different environments or cases [Spiro et al. 1988]. We think that the learning process is a dynamic process based upon actions and problems solving (learning by doing, as said John Dewey [Dewey 1916]).

The pedagogic model proposed by Kolb [Kolb 1984] has been chosen as appropriate for instruction in power electronic’s area. Using this model, multimedia case studies serve as instructional activities that contribute to all of the four process: concrete design examples, reflective observation, abstract conceptualization by links to the theory and active experimentation by multi-dimensional exploration in hypermedia and simulation. Thus, we have created an efficiently environment that can be explored by learners, in which they have tasks to perform, contextual access to knowledge displayed in a hypertext format and access to real experiences by simulation.

Structure and User Interface

Our Interactive Hypermedia Tutorial consists of three modules [Fig. 1]: simulation (by SPICE simulator), problems (or Tutorial) and Hypertext.

The students can navigate comfortably through all the system, that provided them with easy ways of moving from their present location to somewhere else, including other modules. Those facilities for searching and active manipulating of information have implications for the interface characteristics. Therefore, under Microsoft Windows conventions [Microsoft Corporation 1992] for windows managers, we selected design features which not only bring quality appearance, but they account for:

- Efficient navigation schema among data, functions, tasks and roles.
- A comprehensible mental image (metaphor).
- Appropriate organization of data, functions, tasks, and roles (cognitive model).
- Effective interaction sequencing (the feel).

![Figure 1: Structure of Interactive Hypermedia Tutorial](image)

The decisions concerning the design of the interface that hypermedia authors’ can make, will vary with the purpose and content relating information and its uses [Wright 1991]. Thus, the sort of movement that is possible in each module, the kind of content and its uses, differ widely. It's possible establishing three levels to concerning the degree of constrained on possible routes away from the present screen, possible destinations, tasks, extra facilities, etc. Those levels are: User Limited, User partially limited and User Free. For example, Tutorial’s users, must follow any of the specific routes indicated by the system, if they wish to get the goal, that is, be able to complete the questions correctly (user limited), however, for Tutorial purposes allowing the students run many other applications is very convenient (user free).
<table>
<thead>
<tr>
<th>Routes</th>
<th>User Limited</th>
<th>Partially Limited</th>
<th>User Free</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tutorial</td>
<td>Hypertext</td>
<td>Simulations</td>
</tr>
<tr>
<td></td>
<td>Indicated by the system.</td>
<td>Decided by user in order to linkage structure.</td>
<td>Decided by user-supplied parameters</td>
</tr>
<tr>
<td>Destinations</td>
<td>Tutorial</td>
<td>Hypertext</td>
<td>Simulations</td>
</tr>
<tr>
<td></td>
<td>Questions’ solutions.</td>
<td>Any useful nodes of the structure.</td>
<td>Any of the multiple possible results of simulations.</td>
</tr>
<tr>
<td>Tasks</td>
<td>Hypertext</td>
<td>Tutorial</td>
<td>Simulations</td>
</tr>
<tr>
<td></td>
<td>Only read searching informations.</td>
<td>Solving numeric questions, tests, selecting among a limited number of parameters.</td>
<td>Decided by user-supplied parameters (unlimited number)</td>
</tr>
<tr>
<td>Other applications access</td>
<td>Simulations</td>
<td>Hypertext</td>
<td>Tutorial</td>
</tr>
</tbody>
</table>

Table 1: Limitation user’s levels.

**Tutorial Module**

It consists of eleven Practice Units (P.U.), to one type converter dedicated each one. The learner can select which P.U. he wants to explore. Next, he can select one of the difference problems which are proposed in the P.U. Within a problem the learner can study several aspects of a converter by several questions proposed. Moving through all the questions the learner examine the use a concept in different contexts. If he can’t answer one question the system helps him with comments about their errors and it displays the recommendations and signs required to excite the student to research (which resources must explore, what is the formal way for...). In other words, although the system permits the user determine the sequence in which to access information from, it’s involve to adopt the most appropriate learning strategy for their tasks, providing guidance and encouragement to make more than a surface level pass through the material. While solving problems, he has access to Spice simulator, Hypertext and to other of our developed applications such as: calculation tool, animations, and of course, evaluation (that shows his own updated results). Those resources contribute to provide multidimensional characteristics explained above.
Calculation tool

We have made possible to students to access to a mathematical tool for solving questions, Formulario. Selecting the conversion mode, circuit type and load type, it will bring all the related mathematics expressions about the selected converter, to the screen. The user must introduce the parameters of one expressions and the result appears. This useful application is crucial in studying of power electronic’s quantitative aspects. Formulario allows the learner to concentrate on the essential aspects of the learning process rather than wasting time with printed lists and scientific calculator.
The movies add a tremendous dimension to the converters’ study, by time variable. Animation in a multimedia environment is the component which brings across points which cannot be explained in a single dimensions as they are in a book. The available animations show the power converter’ circuit and a moving arrow indicates the circulating current while changing instantaneous voltages. Clicking on the circuit will cause the animation to stop and to continue. They result an effective method in understanding process.

**Evaluation**

Evaluation options of Options menu, allow us to form a view of whether it produces proper outcomes with a reasonable amount of effort in a reasonable amount of time. Errors are detected by the control system, cause a set of variables registers when the user answers each question. He can have three mistaken before a question is countered as fail, and then the system displays the correct response Evaluation P.U. option gives us access to relevant indicators of learning, such as: correct responses’ percent, tries number, first try correct responses, sessions, start time, etc., all of them related with each P.U. Global Evaluation option displays the same parameters related with all the units.

**Hypertext**

Hypertext is a supplementary resource in which learners can extract information they need for solving problems or for understanding their mistakes. So, hypertext functions as a help facility, complementary to Tutorial module. We have made available to students several Themes grouped in eleven Thematic Units (associated with the eleven P.U.s). Each Theme consists of Topics, with the distinctive qualities of hypertext environments, as the ability to click on a word and get more information, or allowing the students to make annotations. Hypertext provides readers with much useful information and offers them many “choices” of route through that information. Readers can easily move around within the information structure, but reader-selected destinations are restricted by a fixed linkage structure. So, readers’ activities are limited trying to locate specific information.

**Simulation module**

Simulations can be an important strategy for providing “authentic experiences” with power electronic’s concepts, cause our representation or understanding of a concept is not abstract and self sufficient rather is constructed from those contexts in which the concept is used [Brown et al. 1989]. In our learning aid for design, analysis and optimization of power electronic converters, PSpice simulator can be used to gain more understanding of the subject under study with variation of system parameters. Simulations files (which have regard to the problems), can be chosen in Simulate menu and the converter configurations can be analyzed and modified with the user-supplied parameters, providing them interesting conclusions. But only knowledgeable in the subject may select and apply know-how properly.

**Conclusions**

Educational software must be design correctly, in order to some basic principles such as: systematic graphics design, provide the user with appropriate navigational mechanisms and structure contents with logical connect. In this paper, we present the design and overview of a learning aid system which was implemented using the commercially available author’s systems: Microsoft Visual Basic and Authorware’s Professional for Windows. Our evaluation studies (that will be explained in a next paper) show that this model supplement successfully the formal lecture given in classroom. Employing interactive system aids is not to replace the teacher with a machine, but to assist and supplement him. Networks expansion, computers’s acceptation among the students, and the increasing devaluation of hardware and software, make necessary this renovation.

**References**


The Design and Evolution of an Authoring Environment and its Applications

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Abstract: This paper describes a rationale behind the design and evolution of an authoring environment called NEAT, which has been developed and used at Acadia University since 1991. We begin by describing the early design of NEAT and various courseware developed with these versions. The main part of this paper describes the design of the newest generation of NEAT, based on our experience with previous versions. This generation includes many new features such as the student model, a prerequisite structure, and others. Our paper will provide a useful description of our experience and contribute towards the development of an "ideal" authoring system.

1. Introduction

Computers have been used in society for instructional purposes for over thirty years, see [Ale91]. There have been numerous studies conducted in order to prove that computers are capable of teaching better than any other traditional method, see [Mau90, Ket91]. As a result of these studies, several types of applications of computer-based materials have surfaced, including classroom presentations with no interactions; electronic classrooms where the instructor interacts with students; and lab applications where students interact with the computer. While there have been many success stories, these studies have also failed to show, in general, the superiority of computer-based instruction over other means, such as, for example, books, teachers, or films. There may be several reasons why computer-based teaching may not be fully effective. One reason may be that not all types of courses benefit from a computer-based approach. Another reason may be that often computer-based instructional systems are designed with emphasis on technology instead of course information.

In this paper, we address the latter reason, and describe our experience with developing and using NEAT (Integrated Environment for Authoring in ToolBook). NEAT is an authoring system based on ToolBook, a popular commercial system, see [Too94]. Courseware created using NEAT will be called neatware. We briefly recall basic features of NEAT and neatware, and discuss the rationale behind our design decisions.

We share our experience with the reader of this paper in the hope that it will be helpful when making decisions about computer-based applications, especially at small universities. Clearly, our project has been rather modest, compared to large scale systems, such as, COSTOC, see [Mau88], and Hyper-G, see [Mau90a]. Nevertheless, we believe that the history of our project has shown that the development of a useful system to test and apply various new ideas is possible and enlightening, even with very limited funding and staff. There were two basic generations of NEAT. The first generation consisted of three versions of NEAT (1.1 to 1.3), developed with ToolBook 1.53, and it is described in Chapter Two. In this chapter, we also briefly describe the implementation, comment on the design based on what we know today, and present several applications that have been developed using NEAT at Acadia University. The second generation of NEAT is being implemented with ToolBook 3.0, and its design is described in Chapter Three. In Chapter Four, we describe the additional facilities for intelligent tutoring systems; a question repository, and a student model. We conclude our paper by describing our plans for future work.
2. Early Versions of NEAT

2.1. Design

NEAT was originally designed by T. Müldner from Acadia University, Canada, and S. Mayer and C. Unger from Hagen University, Germany, in the summer of 1991, and later implemented by T. Müldner as Version 1.0, see [May93, Mul94]. Later versions were designed and implemented by T. Müldner, with the help of many of his students. Because of space limitations, below we merged the descriptions of all three early versions, rather than tried to explain each version separately.

One of the first design decisions was to base neatware's structure on a book metaphor. As in a traditional book, neatware consists of chapters; each chapter consists of sections, subsections and pages; a section consists of subsections and pages. A tutorial page, containing information to be learned, always has the same appearance, with a fixed set of icons at the bottom. We felt that learners are so used to the traditional structure of a "paper" book that hyperspace without a familiar structure would only contribute to confusion and frustration. At the same time, we were convinced that an associative structure of hypertext is very useful for the learning process, see for example [Mau90]. Therefore, we added hypertext links which could be used to move around in the book, allowing the user to access information which may be more relevant. A related design decision was to allow multiple views of a single neatware. For example, one could have a beginner view and an expert view, and think of these views as separate books, between which the user can move. In the real world, the appearance of books can be altered in several ways by the reader. Notes can be kept separate from the book, on a sheet of paper. Notes can also be kept on the margin of each page. One or more bookmarks may be placed, for easy future reference. Words on each page can be highlighted, in one of several colors (this particular activity seems to be favored by most students). We have noted that all of these activities contribute towards a single goal; a customization of the learning material. For this reason, we have decided that the learner should be able to use all of the above facilities (in other systems only authors have this privilege). In addition, the learner should be allowed to customize the electronic index, by inserting new terms and removing existing references. (Later, we have found these tools to be particularly useful for other reasons; see the discussion below). Early on, we recognized two well-known problems of using hyperspace; cognitive overhead, and what we here call a "location" problem. To tackle the former problem, we decided that every neatware should have the same basic appearance, and the user interface, for example; menus and icons should be identical. This decision helped to standardize computer based applications developed later on; an important decision for any institution involved in a production of educational materials. The location problem was partially solved by tools designed for customization and described above. In addition, as each page was read, its name was stored in a list, called the history, from which the reader can choose to return to recently visited pages. Also, the table of contents contained "bread crumbs", or footprints, which showed the fraction of the book that was read. We decided to show the table of contents in a structured way, rather than simply as a sequence of pages. The screen was divided into three panels, and initially, the user saw the list of all chapters in the chapter panel. Selecting a chapter displayed all sections of this chapter in the section panel. Similarly, selecting a section displayed all pages in this section in the pages panel. An issue related to the table of contents was numbering pages. Each page had a name, for example "Mammals in Canada", so we asked ourselves, "was the page number useful at all?" One may argue that, in the presence of a hypertext structure, page numbers are quite useless, but we were not quite convinced and decided to leave them after all. This issue resurfaced when the index was designed. In a classical index, each term has an associated list of page numbers. Since we considered page numbers to play a secondary role, we decided to introduce a special mode of browsing pages, associated with an index term.

At the time the second version of NEAT was being designed, we read a paper by L. Neil about example-based learning, see [Nea89], and decided to incorporate this concept. For every neatware, the author and the learner can create and modify a repository of examples with a hierarchical structure. Later, we found that this concept was particularly useful for teaching programming languages, because in this case one always learns from examples of small programs. In addition, each page of every neatware may contain examples that are used for teaching, and so cannot be modified by the learner. However, the learner can select her or his own preference (the preference may be based on his or her knowledge when studying the book; for example, on knowledge of Pascal or FORTRAN when studying C), and an example may have several appearances, depending on the preference. Finally, we had to tackle the problem of questions. From the theory of cognitive science, we know that questions are essential for transferring the concept being learned from short term memory to long term memory, see [Ale91]. We decided to include six most basic types of questions: multiple choice, fill-in the blanks, numeric analysis, matching questions (where the learner has to match two pieces of information on the screen), text analysis (where the user clicks on specified pieces of text, e.g. spelling mistakes), and position analysis (similar to multiple choice, except the user makes a choice using the mouse). The design of judging
multiple choice questions turned out to be unexpectedly difficult. Consider a question with say five choices, labeled from A to E, and assume that choosing B and D gives a correct answer. What should be done, when the learner clicks B and E, or A and E, or anything else? In other words, how should we design a user interface for the author to provide reasonable feedback for most choices (not all, since this would be too cumbersome)? At that time, we decided that the author would have choice of providing feedback for "context-free" choices (feedback is provided regardless of whether or not the learner selected other choices), or "context-sensitive" choices (a feedback for a specific set of choices, for example A and E). In case the learner selected several choices, feedback provided for context-free choices were concatenated, provided there was no corresponding context-sensitive choice (which would have higher precedence). The author was still left with a horrendous task of providing feedback for all combinations of choices, or using a default "Wrong answer" feedback.

All the design decisions described above were related to the functionality of neatware. What we really wanted to achieve in designing NEAT was to make an author's life easier, see [Mul94]. Thus, we decided that the maintenance of neatware structure (that is, the structure of chapters, sections, etc.) must be transparent to the author. The author can insert, delete, copy and move chapters, sections, and pages without having to modify any of the navigation tools, such as "go to the next page". Next, the development tools do not show up in neatware, so that the user working with NEAT has a clear idea of the appearance of the final product. For this reason, NEAT consists of a series of menus that are used to create pages, objects on these pages, etc. Also, there will be automatic creation of computerized drills using templates for the six types of questions described above. Finally, there will be tools to support reusability, such as a graphics library to store graphic objects, and so-called shelves to store pages which have been removed, but could be reused.

2.2. Applications and Retrospect

In spite of all the implementation problems described above, version 1.3, the last version of the first generation of NEAT, was used to develop several larger applications:

- SLADER, neatware on drug and alcohol abuse, see [MUL93, Vee94]
- C INTERACTIVE, neatware on teaching programming in C
- MN, neatware on teaching introductory programming in Modula II, used for teaching first year students of Computer Science at Acadia University since 1993
- "Introductory electronics", "Graphics, Hypermedia and Multimedia", and "An Introduction to Maple on the AXE Network", see [Vee94]
- COMPILERS, neatware on teaching translators at Acadia University.

In general, the development of NEAT was a very useful experience. First, with a very modest budget, we started using computer-based applications at Acadia University. Using just ToolBook, we would not be able to develop and maintain all these applications. MN went through the most rigorous testing, and has been used as a classroom presentation for teaching introductory programming since 1993. Students have also had access to MN on the university network, and they can download MN for use on their personal computers. During the development of SLADER, we found that the design of neatware was very useful for two purposes which were not thought of before: rapid prototyping and communication with subject matter experts. We prototyped large portions of the material, and then presented it to the specialists on drug and alcohol abuse. During meetings with these experts, we often used tools such as margin notes, global notes, and hypertext to compile comments provided by these experts and to produce the next version.

What are the main drawbacks of the first generation of NEAT? First of all, the book metaphor was taken to the extreme; a more flexible structure would be as useful and at the same time would allow us to implement additional features. The decision to have a fixed set of icons at the bottom of each page turned out to be too rigid. For example, initially only basic navigation icons should be visible; other icons unnecessarily distract the user. Page numbers turned out to be unnecessary, and in retrospect should not be shown. Templates, the question environment for NEAT, was developed by M. Rhodenizer as part of his thesis, see [Rho93]. With templates one could create questions and import them into neatware, but the design was lacking a real graphical user interface, GUI, forcing the author to operate through several layers of menus (this design was chosen because of the lack of proper tools to build GUIs in ToolBook 1.53). More importantly, Templates should be more powerful and provide information necessary to build Intelligent Tutoring Systems, ITSs. To experiment with ITSs, a system called Authoring Tools for Individualized Curricula, ATIC was designed and implemented by L. B. Tan, see [Tan94, Mul95]. This system implemented a student model through a set of DLLs (more on student model in Chapter Four). In ATIC, prerequisites between concepts and topics are represented by a precedence graph, see [Cla93]. Hypermedia were poorly integrated into the system, partially because ToolBook did not provide proper tools for this purpose. When Media Blitz from Asymetrix was released, we started using it, but it was not an ideal solution. Finally, the fact that annotations used for customization, such as highlights,
would not allow us to use neatware in a multi-user environment, was also limiting the popularity of neatware. It was noted that all the annotations should be stored in some form of a database, so that they can be modified "remotely" (for example, the author may wish to modify help window after neatware has been released).

While version 1.3 was being used, Asymetrix released a new version of ToolBook 3.0. Conversion of NEAT as well as neatware described above was painless, and helped to solve many annoying implementation problems, such as lack of local memory. This new version of ToolBook gave us a chance to implement a better generation of NEAT. This generation is described below.

3. NEAT 3.0

In this chapter, unless stated otherwise, by NEAT we mean NEAT 3.0. Most of the work on design of this version was done by C. van Veen, see [Vee95].

3.1. Design

The new version of NEAT has many new features, not available in the previous versions. Most of the changes were made in an attempt to address the problems described above, and to provide some "intelligence". The first major change is in how the information is stored, in attempt to relax the book metaphor. Instead of storing all information in neatware, now information is stored either in a knowledge base or a user model. Each user of NEAT is assigned a separate user model, which stores the dynamic information about that user; for example highlights made by this user. The knowledge base is used to store static information about neatware, and it is shared by all users. The knowledge base consists of units, courses and curricula; curricula consist of courses, while courses consist of units. A unit or course may be assigned as a prerequisite to another unit or course in the knowledge base; similarly to prerequisites in ATIC. It may be required that a prerequisite be completed by a learner before the learner is given access to the unit or course for which the prerequisite exists. Prerequisites can be combined, or selected; for example in order to start a unit A, it may be required that units B and C are completed first; or it may be required that that units B or C are completed first.

We envisage large curricula built by various authors. For a given group of users, it may be useful to extract a part of a curriculum and assign it to this group; something that authors cannot foresee. Thus, we added a new category of users, called instructors. In general, authors define the knowledge base and may add, modify or delete users. Instructors may add, modify and delete learners and make some modifications to neatware in the knowledge base, for example select a goal, that is a curriculum, course, or unit that is to be completed by learners (because of the prerequisite structure, the learner may have to complete various other units or courses before the goal is reached). Finally, learners browse neatware in the knowledge base, receive copies of neatware from the knowledge base, study copied neatware with the option of making some personal modifications, and answer questions (see the next section). Each unit in the knowledge base is represented by a ToolBook book. These books consist of pages, whose design is selected from a page repository. There are several extensions to the way annotations can be created. The source of a hyperlink can be text, a graphic or a button with a special label and style. For example, a button labeled with a paper clip indicates a link to a short, editable margin note. A hyperlink destination may be displayed either sequentially or in parallel with the unit. Sequential display means that the page where the source of the hyperlink is located is hidden and the destination of the hyperlink is displayed. Parallel display means that the page containing the source of the hyperlink is still visible while the destination of the hyperlink is displayed. Finally, users of the previous versions of NEAT were complaining that all author-defined annotations can always be modified by the learner. Therefore, in the current version, the author can decide whether a decoration is fixed or modifiable by the learner.

4. Question Repository and Student Models

Most of the work on design of the question repository and student model was done by K. Müldner, [MuK95].

4.1. Intelligent Tutoring Systems and Student Models

There has been a great deal of research devoted to Intelligent Tutoring Systems (ITSs). ITSs know what and how to teach, providing individualized instruction for each student. In order to provide this individualized
instruction, a student model is required, see [Sel88, Nwa91]. Ideally, the student model should hold all relevant
information regarding the knowledge a particular student has, as well as all information that could affect that
student's learning. This of course is hardly possible, since it is very difficult to even determine exactly what
aspects affect learning. However, it is possible to capture some aspects of a student's learning, for example, low
scores on tests in certain subjects that indicate a weakness in that area or by maintaining a history of the student's
traversal through the courseware. An obvious way to obtain information regarding some part of a student's
knowledge is through questions. The courseware should therefore provide the author with an easy and natural
way to build questions without the hassles of programming. These question templates must support the provision
of feedback and a marking scheme, applied later to a student using the courseware. The system should also
provide some means of organizing the questions created, as well as support for the creation of tests and drills.

In designing NEAT 3.0, we decided that there will be three kinds of questions. Drill questions are
interleaved with tutorial pages to help the student memorize the material, and will not be judged. Pretests can be
used by the learner as a challenge test; if the learner passes the pretest, then the unit is considered to be
completed. Finally, the unit is considered completed if the learner passed the posttest. To create questions, both
tests and drills, the author first creates one or more "question books". Then, questions are imported into the
desired neatware. The next section describes how the author creates all types of questions.

4.2. Repository

The questions are created by the author of neatware using the question templates tool, here called
Repository. Question templates serve two very important functions: they provide the developer with a GUI for
creating different types of questions, tests and drills, and secondly, they guide the developer throughout the
question design process. Partially built questions can be saved as author-customized templates for later re-use.
For each question, the author specifies the mark and the feedback (text, multimedia, or action as such "move to
the beginning of this unit"). All types of questions available in the previous version of NEAT are provided; in
addition, there is a scientific analysis question, for which the student provides an answer to some problem related
to mathematics, computational theory, chemistry, and any other scientific field applicable, by typing the answer
in the "answer" space provided. There are two types of questions of this kind. The first one is called computed
mode, because the answer is computed by a program provided by the author. This may be useful for questions
regarding topics such as regular expressions, where there isn’t a single answer, but a large set of answers. The
second type is fixed mode, since the author provides one answer; that is this answer is not calculated at run-time.
Arguments may also be computed by author-provided functions; for example for "a + b = x", values of a and b
may be generated by a random function, while x is computed by the addition function.

One of the most important contributions of the new design of question templates is its GUI with the
author. When the author wants to create a question, she or he selects the desired type of question from the list of
available templates, and drag's it into the left pane. Now, the user is switched to the selected template. A separate
response window is used by the author to make all the necessary decisions in designing this question. For
example, the author can specify all synonyms; options, such as the exact match is required, or fuzzy matching
and if so what level of accuracy is required. When the author is satisfied with the designed question, she or he
selects the "Save" option from the "Tools" menu, and the Control Panel is shown. The remaining action is
similar to creating a new page.

5. Conclusions

One of the most important questions that we should ask ourselves after four years of work on NEAT is "Was it
worthwhile, and would we do it again?" or "Should you not use one of the commercially available systems?" In
our opinion, we gained a lot of experience, both working on the design and implementation of NEAT and on
developing neatware. We addressed many of the problems with the current CBT systems, and have at least
partially solved them, or have paved the way for a solution. Computers are already permeating our education
systems; we feel certain that a system such as the one we have designed will serve a useful function in it.

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Authoring a Literary Hypermedia Encyclopedia CD-ROM using Hypermedia Modeling Technique

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Abstract: This paper presents the authoring process for a Literary Hypermedia Encyclopedia CD-ROM. The process follows a modeling and design technique for hypermedia applications called HMT (Hypermedia Modeling Technique). First, we describe some problems related to the implementation of this kind of application. Next, we describe the object and the hyperobject models, as well as the navigation model, that are appropriate for hypermedia. Last, we present the implementation of a hypermedia application that deals with literary information in Brazil to show the viability of the HMT technique described.

Introduction

After three decades of research in the hypermedia field, many identified problems haven't been completely solved yet. For example, problems dealing with disorientation, cognitive overhead, interface quality, interactivity and components structure. Great attention has been given to the user's disorientation. Disorientation happens when the user, during navigation in the hypertextual network, [Conklin 87] [Rivlin et al. 94]:

• doesn't know where he is;
• doesn't know how to move on to another place;
• doesn't know where he came from, and/or,
• doesn't know what could be seen from a particular point.

This happens because users of large hypermedia applications have to deal with a huge structure of connected nodes, but the interface typically shows only a restricted view of this structure [Parseye & Chignell 93]. Some solutions were proposed to solve this navigation problem [Nielsen 90]: local and global maps, fisheye views, bookmarks, backtrack, etc. However, these solutions do not guarantee an efficient navigation. They assume that disorientation is intrinsic to navigation, and therefore the user should be offered a mechanism that allows him to be reoriented.

To avoid or to diminish disorientation, it is necessary that the users understand the existing relations among the nodes of the hyperdocument. To achieve this, the developer has to organize the hyperbase in coherent structures. Further more, he has to make these structures clear to the user. Based on hypermedia application development research [Garzotto et al. 93], [Garzotto et al. 93a], [Lange 94], [Schwabe 95], [Isakowitz et al. 95] and in the object oriented paradigm [Rumbaugh 91], HMT - Hypermedia Modeling Technique - was created. It allows the modeling and design of high quality hypermedia applications.

In this paper, we will show how HMT can contribute/help in the construction of hypermedia applications where the risk of disorientation is low (or even non-existent). We will also show how this technique was applied in the literary domain, describing a CD-ROM that we have built.

The HMT

A modeling and design technique for hypermedia applications should help the developer to answer three fundamental questions [Isakowitz et al. 95]:

1. how to divide the information domain in nodes;
2. how these nodes are connected, and
3. how the user interacts with the application.

The HMT uses four models to describe an application: the object model describes the domain application objects and their relationships; the hyperobject model refines the object model, adding more semantics to the relationships; the navigation model describes the links and access structures; and the interface model contains the descriptions on how the user will perceive the hypermedia objects.

The Object Model

The HMT object model uses the concepts and the notation of the OMT (Object Modeling Technique) [Rumbaugh 91] object model. This model describes the structure of objects in a domain - their identities, relationships to other objects, attributes and operations. An object class describes a group of objects with similar properties, common behavior, common relationships to other objects, and common semantics. The classification of objects depends on the purpose of each application. The purpose of object modeling is to describe objects. This is achieved by the use of object diagrams, as is done in OMT. The concepts of class, attributes, operations, association, cardinality, generalization and aggregation are used. One of the main advantages that the object model brings to hypermedia is the fact that the relationships are treated as explicit constructions, and not as attributes in each class.

The object model captures the application domain semantics. In the point of views of hypermedia, each class of the object model is a candidate to be mapped in one or more types of nodes; but also many classes could originate only one type of node. Associations are candidates to be links or access structures, depending on the cardinality and the desired kind of access. The important thing is that this kind of design decision is not done in the object model.

The HyperObject Model

The hyperobject model is a refinement of the object model. As there are a lot of applications that already have the object model, the hyperobject model could reuse it. Besides this, many project decisions are included in the hyperobject model. The emphasis here is:

- defining new classes and associations that define desired paths (not captured by the object model);
- identifying the media that will be used, and
- identifying abstract classes.

The Navigation Model

Associations are the "glue" of the object model [Rumbaugh 91], providing access paths between objects. Associations are conceptual entities useful for conceptual modeling. However, during the navigation modeling phase, some strategies must be created to guide the implementation of these associations. In the object model, an association is an abstraction that indicates that one class is related to another one. But, in the design perspective, how should an association be represented? As a link? As a group of links? As an access structure? We should carry out a careful analysis of each association, taking into account the way they will be used in the application.

Besides this, we define navigation contexts in this model. These contexts are used not only to enhance the links semantics, but also as input to the interface model. The idea of navigation contexts is inspired in the "Art Gallery" application [Microsoft 93] and in [Schwabe 94]. Every object is part of a default context and could be associated with other contexts. The navigation can be context-sensitive or context-independent. In the first case, navigation respects the current context. In the second one, while traversing a link, it takes up the default context of the destination object.

Finally, we have to define the application entry-points. Each context can define one entry-point, according to the application requirements. These points indicate from where it is possible to start navigation.

The Interface Model

Users could be seriously constrained by the divisions of the material predetermined by the author, where a particular piece may be viewed in many different contexts, or arrived at different routes [Woodhead 91]. Designers must consider not only the structure, which must be shown explicitly to the user, but also the way
information should be presented, considering the user context in any part of the hyperbase. Therefore, some mechanisms are necessary to keep a sense of consistent and absolute orientation in the information labyrinth.

Using the interface model, the developer describes how information will be presented to the user. Interface design involves layout definitions of the screens, the appearance of the objects and the visual identity. This definition is based on the hyperobject and on the navigation model.

The Literature CD-ROM

A literary application was developed - modeled, designed and implemented - by using HMT. This was done to evaluate the practical use of the technique. The result became a CD-ROM: the multimedia encyclopedia of Brazilian literature. In this section, we will describe this development, as well as the results. The interface model, not presented in this paper, can be found in Nemetz 95.

The application

The application implemented should allow the user to access information about literature, more precisely, Brazilian literature. It should be possible to check authors and books. Authors are classified in periods: XIX Century, Regionalism, Romance of the 30's, and Contemporary Fiction. Besides this, it should be possible to access associative information, such as authors that are related to others, or authors from a particular literary period. For each book, there should be a review and a summary. And, if convenient, some excerpts that illustrate a specific aspect. Also, a full-text search should be possible. The book covers should be presented, as well as pictures of the authors. And the passages should be read by a narrator.

The Object Model

The object model is built as is recommended in Rumbaugh 91: (1) identify object classes; (2) identify associations; (3) identify attributes of objects and associations, and (4) organize and simplify classes using inheritance. The object model for this application is shown in Fig. 1.

The HyperObject Model

To build the hyperobject model, we must analyze each class defined in the object model, checking if all desired access paths are part of the conceptual model. If the answer is no, then we have to add new associations and/or classes. In our application, if we want to know a specific book from an author, we should access his literary production. In many cases, this path will be very common: from an author, we find his production and, then we explore the books that we want. However, we should anticipate one possibility of access that makes a
direct association between the author and a particular book. So, to represent this intended new path, an association between Author and Book should be added.

Another aspect treated in this model is multimedia. Using the hyperobject model, the developer expresses his decisions about several media that take part in the final application. We should then analyze the classes that will have multimedia data. In our model, three classes will have multimedia representation: (i) an author can be seen by a portrait and, if possible, by a video passage; (ii) a book is presented also by its cover, and (iii) a passage should be presented in audio format, besides text. HMT represents these decisions using the aggregation concept, as shown in [Fig. 2], for the Passage class.

![Figure 2: Adding different media](image)

**The Navigation Model**

In the navigation model, each association is analyzed according to its cardinality and direction. The cardinality (1:1, 1:N or N:M) is directly extracted from the hyperobject model. But the direction of the association - uni or bi-directional - is a project decision made in the navigation model. An association is uni-directional if it is only possible to traverse it in one way. An association is bi-directional if it can be traversed in both ways. The association "refers to" (Author-Author) is defined as uni-directional. This means that, from an author A, it is possible to access other authors A "refers to". However it is not possible, from author A, to access authors that "refer to" A. On the other hand, the association "wrote" (Author-Book) is bi-directional. It is possible, for example, to traverse from Author to Book, if we want to know which books were written by an author. The converse, Book-Author, allows us to know the author of a particular book.

**Navigation Contexts**

One way to decrease (or avoid) disorientation is the definition of navigation contexts. We should, therefore, pay special attention to this step. There is no direct relationship between classes of the hyperobject model and contexts. A context can be defined by a class or by a group of classes. In some cases, a class can originate more than one context. In our application, four navigation contexts were identified: (1) Literary Periods, (2) Authors, (3) Books and (4) Themes.

After the definition of contexts, for each class of the model a default context should be assigned. For example, the default context of the Author class is Authors. However, the Author class can be associated with other contexts. For example, if we are consulting the period Romance of the 30's and we want to know the authors from that period, we must remain in the Romance of the 30's context, and the authors accessed are from that period.

A book has Authors as its default context, even though we could imagine it would be Books; in this case, a book is associated with its author, before it is a book per se. Other contexts associated with Book are Literary Periods, Themes and, of course, Books.

Using the concept of navigation contexts, we could define context-sensitive navigation and context-free navigation. In the first one, it takes into account the current context, so the user does not get lost. In the second one, the new context is the default context. It is used when there is no relation between the current context and the new one.

**Types of Links, Access Structures and Navigation Diagram**

Each association can derive a link, a group of links or an access structure (e.g., an index or a guided tour) [Isakowitz et al. 95]. Besides that, each association defines a type of navigation (context-free or context-sensitive). These decisions are made in the navigation model. Furthermore, we define the entry-points, or in
other words, the initial access to the application. Finally, we draw a diagram called navigation diagram [Fig. 3]. We use the symbols defined in [Isakowitz et al. 95].

We use the symbols defined in [Isakowitz et al. 95].

Results

The results we have obtained by using this technique are very impressive. Users feel very comfortable navigating in the hyper-space. There is no cognitive overhead, and the risk of disorientation is almost inexistent. The interface is completely based on the object, hyperobject and navigation models. Therefore, it is consistent, uniform and simple [Fig. 4].

Conclusions

A modeling and design technique - HMT (Hypermedia Modeling Technique) was presented. Through the development of a CD-ROM, it proved to be a powerful tool.

In the past few years, there were several proposals of techniques, models and methodologies for the development of hypermedia applications: HDM [Garzotto et al. 93], HDM2 [Garzotto et al. 93a], RMM [Isakowitz et al. 95], EORM [Lange 94] and OOHDM [Schwabe 95]. HMT contributes with these proposals through these features:

- identification of four models for specifying a hypermedia application: object, hyperobject, navigation and interface;
- use of the object model of OMT to capture the application domain semantics;
- explicit treatment of the multimedia aspect in the hyperobject model, with specific object classes;
specification of the navigation through semantics enrichment of the associations and the definition of navigation contexts (context-free and context-sensitive).

Our first experience using HMT, the development of a Literary Hypermedia Encyclopedia CD-ROM, was very successful. Our emphasis on research now deals with the interface model, which was not treated in this paper. Another aspect that should be investigated is the use of HMT in different domains, such as cooperative work. We are using the operations of the object model to specify the behavior dimension of a cooperative work tool.

References


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Linking Models to Data: Hypermodels for Science Education

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Abstract: Students today are awash in data. Information floods them from every side. But data is useless without structure, facts are meaningless without conceptual frameworks—information is not the same as knowledge. This article introduces a new paradigm for educational technology—the hypermodel—that seeks to use the computer to bridge the gap between a model and the physical world the model represents, between the “facts and figures” offered us by the natural world and the mental associations we construct to explain them. The hypermodel uses a computer to help them turn that information into knowledge. One particular implementation of this kind of knowledge building is the inclusion of semantic links within multimedia segments. These links enable the computer to “know” the content of the segment, so that it is dynamically connected to the interactive computer model, opening the possibility for a whole range of truly interactive, multimedia learning experiences.

Introduction

An important goal of science education is to influence students to think like scientists. There is considerable evidence [Chi et al., 1981] that when professional scientists think about their discipline they organize experimental data using mental models to link otherwise disjoint facts, suggest causal relations, expose patterns, and provide explanations for processes and phenomena. It behooves the science educator, then, when presenting scientific “facts,” to do so in the context of an appropriately detailed model, and to ensure as far as possible that students acquire both facts and models in the course of their learning. These twin goals—teaching facts and teaching models—are characteristic of two of the ways in which computers are commonly used in the science classroom: either as information retrieval devices (CD-ROM or the Internet) or else to present models of real-world phenomena in the form of simulations [Simmons and Lunetta, 1993]. But neither of these modes captures the complex interaction of model and data that characterizes a biologist’s concept of a gene, or a physicist’s view of a black hole.

Supported by a grant from the National Science Foundation, our group working at Bolt Beranek and Newman, have been implementing and exploring the use of a new technology we call a “hypermodel” that links the act of data retrieval to that of model building by coupling representative real-world data to an underlying model of process. When additional models are also included in this schema—each focusing on a particular process—a comprehensive modeling environment emerges, which allows exploration of many related phenomena of varying scale and scope and from many different contexts. At present this new technology exists only in the form of a prototype program called GenScope that is intended to help students learn genetics. Over the next few years, we plan to enhance this software in significant ways, integrate it with curricular modules and student activities, and evaluate its effects both on pedagogy and learning outcomes. Our long term goal is to demonstrate the educational effectiveness of the hypermodel paradigm as a complement to the traditional textbook, and to implement the tools, protocols, and standards necessary to enable other researchers, teachers, curriculum developers, and students to develop a wide variety of hypermodels of their own design.

Description of GenScope

Many of the barriers students face when they learn genetics are consequences of the fact that the phenomena under study take place at many different levels of description. This multi-layered aspect has made genetics a rich domain within which to study student problem solving [Stewart & Van Kirk, 1990]. In devising software to help students with this difficulty, we have considered six such level-specific models: the molecular, chromosome, cellular, organism, pedigree, and population levels. At each of these we have devised representations of the
information available, as well as tools for manipulating that information. The information is shared between the levels, linking them in such a way that the effects of manipulations made at any one of them may immediately be observed at each of the others. The levels thus combine to form a seamless environment for genetic exploration.

Enter the dragons!

To illustrate genetic phenomena the GenScope program starts with a fictitious species—dragons. These creatures have been given a simple structure that is useful for teaching purposes and will not prematurely raise such sensitive issues as the pros and cons of genetic engineering or the appropriate use of genetic screening tests. Our pedagogical approach has been to present students with a carefully sequenced set of problems to solve and then to set them up, two or three to a computer, and let them work on them. For example, using a model of Mendelian genetics we may challenge students to create dragons with specific traits, or to trace a family tree in order to determine the location of a gene that is responsible for an inherited disease.

Figure 1: GenScope’s organism level. Two organisms are shown—in this case dragons. Their appearances are determined by their genes, which can be viewed and altered by the students.

Students are generally introduced to GenScope at the organism level (see figure 1), which displays the organisms’ phenotypes (physical traits), but gives no information at all concerning their genetic makeup. Using a specific tool, the students may observe a single cell of an organism, as represented in figure 2. The cell contains chromosomes, made up largely of DNA molecules that contain all the genetic information carried by the organism. The cells represented on the computer can be made to undergo either mitosis, simple replication, or meiosis, in which process they produce a new kind of cell, called a gamete, which possesses only a randomly selected half of the chromosomes (haploid) of the parent cell. Once formed, the gametes can be combined in the central panel of the cell window, to produce a fertilized cell, or zygote. The zygote, in turn, will grow into a dragon possessing genetic material inherited from each of its parents. Meiosis is particularly difficult for students to understand, in part because although it is a cellular process, it involves processes that take place at the chromosomal and molecular levels, and its effects are felt at the pedigree and population levels.

Figure 2: The cellular level of GenScope. Shown are one cell each from Eve and Adam, the two dragons depicted in figure 1. The cells, each containing strands of chromosomes, can be made to undergo meiosis or mitosis. The computer runs a randomized simulation of gamete formation.
Thus, it is central to the field of genetics and a good deal of attention has been paid to it in the science education research literature [Kindfield, 1994; Liberatore et al. 1994]. Meiosis is represented graphically in the form of a computer animation, as shown in figures 2 and 3. The animation does not, however, attempt to represent the full complexity of the process, nor does it look exactly like meiosis as it appears under a microscope.

The role of the hypermodel

It is good for students to learn about meiosis by looking at a computer animation, but it is also important for them to know what a real cell looks like under a microscope, and how it divides. It is vital for them to realize that the real world is not as simple as a computer representation, that the information one seeks is often obscured by confusing and extraneous evidence, that interpretation of data is generally not as straightforward as it may appear in textbooks or in carefully arranged classroom experiments.

Figure 3. Meiosis is in process in this snapshot of the cell window. Adam’s cell, on the right, has already produced the four gametes; Eve’s cell, on the left, is about to complete the second division.

Most high school biology laboratories have at least one microscope, and it is possible—and advisable—for students to use this to view cells. But it is nearly impossible to set things up in a classroom so that one can watch an actual meiosis—mainly because, the process takes too long. So it is educationally valuable to store a short movie sequence of this process on a CD-ROM and let students view it on a computer.

What a hypermodel can do, however, that is not attempted by the conventional multimedia packages is to link a movie of cell division to a computer model of the same process (figure 4). On the left-hand side of the window is a QuickTime movie of a cell undergoing meiosis. In the righthand pane of the window is the computer model’s version of the same thing. As the student manipulates the scroll bar underneath the movie, both the movie and the model move through the various phases of the process. This is accomplished by the inclusion of data that resides in both the header and tracks of the QuickTime file, thus providing the link between media and model. The model is not just a “cartoon” version of the movie; it still retains all its former functionality. For one thing, it is a random process—the chromosomes migrate to different gametes and undergo recombination each time it is run. The computer model, in other words, is a live, manipulable object, whereas the movie is stored data—static and immutable.
Biological structure and information content

At the cellular level, GenScope represents chromosomes as they appear in nature—as squiggly “spaghetti strands” in the nuclei of cells. But the importance to genetics of these biological structures stems from their role as carriers of information, and for this reason they are often depicted in textbooks as stylized rectangles with positions marked on them representing the locations of various genes. GenScope incorporates this representation as well, but with two important differences: the genes so marked may be altered by the student, producing corresponding alterations in the organism itself, and the chromosomes may be “opened up” (i.e., accessing the molecular model) to reveal the underlying structure of genes as sequences of DNA.

In figure 5, for example, we see GenScope’s version of the textbook depiction of a pair of chromosomes as rectangular objects, schematically representing the linear DNA molecule, with the genes marked at their respective locations. However, anyone familiar with the Macintosh interface will notice that the labels marking the genes are actually pulldown menus. Activating these enables the student to change the gene from one variant, or “allele,” to another. Such changes are accompanied by changes in the appearance of the organism to which the genes belong, as appropriate. Thus, an alteration of the wings gene in chromosome 2b, below, from the “W+” form to the “w” form will cause the wings on the dragon to disappear. We have observed students to figure out for themselves the classical Mendelian rules governing the behavior of dominant, recessive, and co-dominant alleles, as well as more advanced topics, simply by playing around in this way with the various genes.

Seen at the chromosome level, as above, genes are simply “markers” of some kind—their exact nature remains as mysterious to students as it was to Mendel and his colleagues. The true nature of the genetic mechanism resides, as we now know, at the molecular level, and GenScope enables students to drop down to this level to explore the DNA molecule that is contained within each chromosome. Figure 5 shows Eve’s two genes for wings, for instance, showing what the “W+” and “w” alleles look like at the DNA level. They differ, but only very slightly.
Figure 5. The “informational” representation of a pair of chromosomes. Note that the labels on the genes are pulldown menus, which allows students to change them and view the alterations, if any, in the affected organism.

The DNA level has two complementary representations (not shown): a physical representation that shows the molecule as strings of colored rectangles representing the base pairs strung out in a linear array, and an informational representation in which the bases are displayed as a linear sequence of the letters ATGC, the initial letters of their names: adenine, thymine, guanine, and cytosine. The tension between representing biological reality and emphasizing information content is reminiscent of the contrast between “chromosome as spaghetti” and “chromosome as rectangle” presented above, and indeed it permeates the GenScope program throughout.

Just as the informational representation of a gene can be manipulated, via pulldown menus, so the equivalent representation of a DNA molecule can also be altered, simply by deleting or inserting the appropriate letters, typing them in as one would with a word processor. In this way, alleles can be altered at the DNA level and the changes will seamlessly be reflected in the organism just as though the gene had been altered directly on the chromosome, using the pulldown menu. Mutations created at the DNA level are treated as new alleles. They can be named and used just as the pre-defined ones can. (Their default effect is to mimic the recessive allele, but GenScope includes pre-programmed mutations that cause, among other things, albinism.)

Dragon DNA is purposely designed to be as simple as possible, while still illustrating certain central points. GenScope, however, can also represent other species, and when it does so the DNA can be derived from actual sequencing data. We have done this in a few cases, most notably the representing the normal and sickle cell alleles of the human hemoglobin beta gene. This is another example of the close connection between GenScope’s internal model of genetics and real-world data. We have also included the ability for students to access DNA and protein sequences as well as molecular structures from on-line genetic databases, and automatically convert this data into contextualized objects for fast integration into organisms or molecular models. This will permit teachers and students to analyze, interpret, and utilize real genetic data without the need for complicated networking or analysis tools.

Pedigrees and populations

As we have seen, organisms can be mated by combining gametes at the cellular level to produce a fertilized zygote. The resulting offspring will exhibit the traits appropriate to the particular mix of alleles it has inherited from the parents. This process is somewhat laborious (though instructive) and produces only one offspring at a time. For statistically oriented studies of inheritance GenScope’s pedigree level is considerably more useful (see figure 6). This is also the logical level for the introduction of genetics puzzles involving probability theory.

At this level female organisms are represented by circles, males by squares. A single phenotype, selectable by the user, can be represented schematically by full or partial filling of the icon representing the organism. Any two organisms of opposite sex may be mated to produce a preset number of offspring. The genotypes (the set of alleles), and therefore the phenotypes (physical traits), of these offspring are randomly inherited from the parents. Their chromosomes and DNA can be examined in just the same way as before, because the corresponding (chromosomal and molecular) models are also linked to the pedigree model, permitting one to “see” the genome inside each organism. Organisms can even be dragged with the mouse across models onto the organism level, where they are displayed with their full phenotype as the others are at this level.
Figure 6. The pedigree level. Note that one of Adam and Eve’s daughters is stillborn, due to a sex-linked lethal gene.

At the population level (not shown), GenScope represents organisms by smaller circles and squares, which once again can be made to show a particular phenotype. This level introduces time and space, however—the organisms can be made to move about on the screen, randomly mating with each other. Moreover, different portions of the screen can be assigned different “environments,” which selectively favor one or another phenotype. When we run a population of animals with randomly chosen genes through many generations we find evidence of “genetic drift” which causes wings to predominate in the mountains, while “snakes” flourish in the swamp. The organisms themselves can be dragged onto the other two levels, as well, where they are represented in the same way as organisms that were “grown” there. This is particularly useful in the case of the pedigree window, because it enables one to see how a particular trait “arises” in a population. Again, this is all possible by virtue of the interlinking of different level models, central to GenScope’s internal structure.

Other Uses of Hypermodels

At this writing we have applied our model to three species: in addition to the fictitious dragons we have created files for humans and fruitflies. Clearly, these real species, as well as the many others that we plan to add in the near future, offer excellent opportunities for linking visual data to GenScope in the form either of stills or of short movies that illustrate the various phenotypes. In addition to electron microscope pictures of molecular phenomena, video clips of laboratory procedures for isolating, purifying, and sequencing DNA could be linked to the GenScope model, offering students an introduction to biotechnology while at the same time emphasizing the indirect nature of experimental data and the complex chain of inference underlying most scientific models.

It is all too easy, in studying the science of genetics, to lose sight of its human dimension. As the Human Genome Project vividly demonstrates, advances in locating and identifying human genes can have unexpected and sometimes soul wrenching consequences for individuals who are at risk of acquiring or transmitting genetically inherited diseases. Decisions with respect to genetic screening—for oneself, one’s parents, one’s mate, one’s unborn offspring—are portentous and fraught with uncertainty and fear. Informed judgments often differ markedly as to what tests should be performed and who should be privy to the results. The ethical, social, and moral dilemmas brought about by advances in human genetics cannot be “solved” by science alone, but they arise in a scientific context and are affected by scientific judgment and fact.

A hypermodel can help to illuminate and guide discussion of social and ethical issues by embedding model-based exploratory activities within a real-world context. For example, to illustrate the dilemmas caused by advances in identifying the gene responsible for, say, Sickle Cell Anemia, we might link GenScope’s internal model to a set of video clips of real people (or actors) who suffer from the disease, or are at risk of developing it or handing it down to their offspring. Connecting such a video to a realistic and manipulable model can serve not only to demonstrate the power of the science, but to aid young people to grapple with difficult moral decisions in a safe and informative context. In this way we may perhaps approach a “holy grail” of science education—placing complex scientific subject matter in a broader societal context without trivializing either. Eventually, we anticipate that students will themselves be able to obtain and link into GenScope resources—such as digitized
video and genetic data—pertaining to a specific topic or phenomenon, thereby giving them the opportunity to contribute the information and knowledge they have amassed to a larger scholastic community.

References


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School Work: Learning and Leading in an Information Age

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Abstract: This paper records and analyses how one school, an inner suburban Australian school, is responding to a vision of school work as preparing children for an Information Age. The focus is on the incorporation of multimedia technology into the curriculum. There is much already known about how learning occurs and how functional learning environments can be created to mediate the learning experiences of children. This case study describes the roles teachers and technology have in mediating student learning and the actions that teachers and managers must engage in when innovation and change become part of conservative professional lives. The concepts of transformative learning and transformational leadership are central to how the school has incorporated multimedia technology into the curriculum. The use of technology in schools needs to be grounded in those practices that enable children to learn, supported by teachers and managers, and a diversity of resources in a functional learning environment.

Introduction

Moonee Ponds Central School has been a pilot school for five years in the LinkWest Project. The LinkWest project (Hooley and Toomey, 1993) is a joint venture between the Australian Centre for Computer Enhanced Learning (ACCEL), located at the Victoria University of Technology (VUT), the Directorate of School Education (DSE), and the IBM computer company. In 1991, 1992 and 1993 one classroom had three computers with multimedia software available for use by teachers and students. In 1994 all classes from Prep. to Year 6 had multimedia authoring hardware and software available for use in the curriculum. In 1995 the DSE selected Moonee Ponds Central School to participate in the Classrooms of the Future project (DSE, 1993). The DSE funded a local area network to be installed at the school and IBM provided the educational software that teachers selected to be used in the curriculum.

The research school, as part of the LinkWest Project and as a DSE trial school, agreed to evaluate the use of the multimedia authoring hardware and software as a technological and cognitive tool. The research questions focused on the theory that learning outcomes for students are enhanced by the use of the multimedia authoring technology. The outcomes from these projects are informing the local, national and international debate about the role that emerging technologies can and will have in reshaping the definition of education into the 21st Century.

The partnership with VUT provided the school with technical assistance and professional development for the teachers. Student teachers were placed at the school for their work placements and assisted teachers and students in the curriculum use of the multimedia software. The partnership enabled educational researchers to observe, record, analyse and interpret the effect of multimedia technology on the work of the students and teachers.

What might computer enhanced learning be?
Schools provide a formal setting for children to develop the skills of literacy and numeracy. They learn to read and write and to use numbers for a variety of purposes. They also learn information about their world in a range of specific learning areas. This is what schools are expected to do to assist students in their intellectual growth and development. There have been a number of reports (Mayer, 1992; Candy, 1994 and Business/Higher Education Round Table, 1991) that have sought to clarify the range of other skills and attitudes that formal learning environments should develop in students.

These expectations expand the responsibilities of schools to prepare students for an Information Age where technological change is rapidly dating existing knowledge and skills. These abilities enable learning to be viewed as a lifelong endeavour. The school curriculum and the use of emerging technologies should provide for these skills to be developed at the same time as traditional knowledge and skills are developed.

Learner-centred, but teacher-guided approaches to teaching and learning were advocated by Dewey (1910) and can now be applied to the use of computers in education. Dewey developed his theory of inquiry and lifelong learning in response to the need to change schooling for the era of the Industrial Revolution. Rowe (1993) suggests that, as in Dewey’s day, education is in need of fundamental change that is guided by research on student learning with emerging cognitive tools that mediate learning (Vygotsky, 1962).

Hooley (1993) has described the use of multimedia technology as a cognitive tool that adapts the technology to support learners in constructing their own view of the world by promoting inquiry. He calls this type of computer use computer enhanced learning, CEL. If multimedia enhances learning it should enable learners to use the technology as a cognitive tool to develop their curiosity and shape their own patterns of learning as they interact with cooperatively constructed, and then reconstructed, multimedia representations of the products of their inquiry (Toomey, Mahon and Thalathoti, 1994). Teachers and researchers at the school have been asking the question: Is the learning enhanced?

The School

Moonee Ponds Central School, established in 1919, has a population of 350 students. Students come from a large residential area in the inner north-western suburbs of Melbourne, Australia. The school offers programs to students from Preparatory to Year 8 in eight learning areas: English, Mathematics, Technology, Science, Health and Physical Education, Study of Society and the Environment, The Arts and Languages other than English (Italian). Features of the Prep-Year 6 programs include open plan design areas, multi-age classes, team teaching and an integrated curriculum.

Students at the school come from varied economic, social and cultural backgrounds. Staff at the school are representative of a range of teachers in terms of age, length of service, use of computers, personal theories and approaches to teaching and learning. Additional resources have been provided to the school through the partnership between VUT and IBM.

The present School Charter is the basis for all decision making at the school level. The mission of the school is:

To provided Prep - Year 8 students at Moonee Ponds Central School access to schooling with planned and high quality teaching and learning experiences that;

a) develop the skills of thinking necessary for continued learning
b) develop the knowledge and understanding to interpret our world
c) develop self-management skills that will allow students the freedom to advance their interpersonal relationships and evolve those value systems that enable them to actively participate positively in society.

The school brings together a combination of situations that should enable the use of multimedia authoring technology to enhance the learning:

- availability of appropriate technology in every level of the school in sufficient numbers to provide access for all staff and students
- a curriculum policy that is based on an integrated approach to learning and teaching
- school leadership that enables the technology to be used by staff and students
- networks of teachers planning for the integrated use of technology in the everyday curriculum
a policy on student learning that supports student-centred approaches
assistance through the ACCEL/IBM Project to provide professional development for classroom teachers
additional student teachers with computer expertise to work with students on their multimedia projects
community support for the LinkWest Project
a school culture that supports the teacher as researcher to constantly reflect on the outcomes from the student multimedia projects.

How has multimedia technology been used in the curriculum?

In 1991 the school started using multimedia authoring software, Linkway Live, in the curriculum of the Year 3/4 classroom. This level of use continued in 1992 and 1993. The selected teachers engaged in an action research project (Kemmis and McTaggart, 1988) to evaluate the use of Linkway Live. The positive learning outcomes for the children led to the project expanding in 1994 with multimedia authoring technology available in each Prep-Year 6 classroom. Student teachers from VUT assisted with the use of the technology and learnt about an integrated curriculum approach to classroom teaching and learning. Each year the school decides on the Prep-Year 6 School Topic. In 1994 the school was celebrating its 75th anniversary and it was the International Year of the Family. The topic was Our History. The 1995 topic was Our Living World. In each classroom from Prep-Year 6 the children used Linkway Live to construct multimedia documents about what they were learning in the focus topic.

Each topic investigation started with the teacher brainstorming with the children what they already knew about the focus topic. Then the children discussed what they wanted to know and how they would collect this information and then present it as a Linkway Live folder to the rest of the class. The children rotated the roles taken at each computer session. Each conference group kept a daily logbook for their computer work. Each entry had to report on progress, reflect on what was achieved in the session and detail what would be done in the next session. Each student kept a learning diary to record responses to specific questions about the skills they were learning with the multimedia technology and how effectively their group was working when they were using the computer.

At the end of the topic each conference group presented their folders to the class. They explained their information and how they had gone about finding the information they wanted. The audience members took it in turn to act as a critical friend when the presentation was finished. The role of the critical friend was to indicate two things about the investigation and presentation that were positive and one thing that could have been improved. The presenting group explained what they had learnt about the topic, the investigation methods and the technology. They were also expected to detail what they would do differently next time. The teacher recorded classroom observations about individual student learning in their teaching diary. The teachers were able to observe and record each student’s co-operative working skills and conflict resolution skills and how the children took on peer tutoring roles. They also recorded the children’s technology skills, problem-solving strategies and cognitive development. All this information was used to compile a comprehensive student profile and to plan the next learning cycle.

What are the children learning?

Teachers recorded the transferable and technology skills that children developed when using the multimedia technology in an integrated way with the rest of the classroom work. The generic or transferable skills included; goal setting, problem identification, working in a group, negotiation, conflict resolution, time management, self reflection, peer tutoring, peer evaluation, co-operation, job/task sharing, presenting information using technology, information sharing, designing research and using creativity. The technology skills included; file management, accessing appropriate software, printing, scanning, video capturing, graphing, presenting information, designing an interface, constructing a multimedia folder, page designing, creating interlinking buttons, text windows, creating pictures using paint software, transferring pages and files, using a network, securing data, sharing data and information, constructing tables, scrolling text windows, document designing and retrieving information.

The outcomes from a mathematical investigation is an example of the range of mathematical skills the children developed as they constructed and reconstructed their multimedia presentations. These mathematical skills
included; measuring, recording, graphing, sorting, selecting, grouping, surveying, comparing, calculating, explaining, analysing and data reliability. The records that teachers maintained were used to report individual learning outcomes in each specific area of study.

Does the use of multimedia authoring technology enhance learning?

This case study indicates that the classroom that is designed as a workplace for learning will effectively use the technology of multimedia. Simply having the technology available is not enough. Leadership in curriculum uses of information technology is essential for enhanced learning. The beliefs that teachers have about learning and teaching will determine how the technology is used. These beliefs can be enhanced and sometimes transformed by effective professional development programs. The need for learners to construct their own meaning with a range of tools is a central idea if the use of multimedia is to enable enhanced learning. The technology tools incorporated into the curriculum at Moonee Ponds Central is supported by a school policy of an integrated curriculum approach to planning for learning. Students have the opportunity to develop information literacy skills (Breivik and Senn, 1994) and have learned how to learn.

Staff and students at Moonee Ponds Central School in Prep-Year 6 overwhelmingly agree that the multimedia technology has enhanced the learning outcomes for teachers and learners. The diversity of learning tools available in the classrooms provide learners with the opportunity to develop learning to learn skills. Students can:

- identify the need for information
- find information needed to conduct an investigation
- organise the information
- analyse the information
- evaluate the information
- use the information effectively
- use technology appropriately to communicate their ideas
- compose and publish interactive multimedia texts

Information literate students will be lifelong learners, empowered for effective decision making, for adopting available technology and for participation in an information rich society.

What learning has occurred for the teachers?

Alongside the changing use of computers at Moonee Ponds Central School has been a corresponding change in teachers’ perceptions of learning and the role of the teacher in that learning. What began in one or two classrooms with one or two teachers of like mind has changed the teaching practice of other teachers in other classrooms. The school has moved from a traditional teaching and learning base to one that is more student-centred. The type of action research that the teachers engaged in has transformed many of the classrooms from teacher directed environments to classrooms where teachers and student teachers work with their students to integrate computer usage into the curriculum, to use the technology as a tool for inquiry and investigation and to display curriculum learning; as a learning tool. This is transformative action research (Stevenson, 1995) that leads to teachers engaging in experiences and critical reflection that transform their beliefs about learning and teaching.

What style of leadership has enabled this learning?

The school leadership provided an enabling environment that supported the integrated use of computers in the whole school. The School Charter, the integrated curriculum policy and the technology policy provided the framework for the incorporation of multimedia into the curriculum. The most significant aspect of all the changes to the teaching and learning environment has been the increasing number of computers in each classroom. The expectation from the students and teachers is that the technology will be used and that it will be integrated into the classroom work of all students and teachers.
The school leadership has supported teachers to critically evaluate the use of the technology and to work in teams to implement school policy on curriculum uses of computers. The school leaders have made a priority of ensuring that the technology is reliable and all developments are effectively communicated to the school community. This is to ensure that all teachers are aware of the developments and have the opportunity to be involved in, and informed about, the technology. These strategies have meant that each stage of information technology use in the curriculum has been understood and supported. This style of leadership that supports change and organisational learning is described as transformational leadership (Avolio, 1995).

The educational researchers that have been working with the multimedia projects at Moonee Ponds Central School have developed a framework of the elements and interactions that enable computer enhanced learning. This type of learning environment is characterised by a culture of learning through inquiry and critical reflection (Schon, 1992). Learning is recognised as a social activity with identifiable interactions occurring between students, teachers, managers and the technology.

The identification of the elements and interactions have led to the development of a model of transformative learning and leading that creates a learning culture appropriate for an Information Age.

Conclusion

Learning in this study refers to the development of students, staff and the organisation. It is recognised that organisations do not learn, it is the culture or climate of an organisation that one can make sense of as a learning organisation (Senge, 1990). Characteristics of a learning organisation are the sum of the elements that create that climate. The congruent concept for each form of development can be traced to Dewey’s theory of inquiry (Dewey, 1910) and a cycle of learning that involves planning, acting, observing and reflective thinking.

The concept of learning by inquiry is further developed through the work of Lewin (1951), Piaget (1977) and Kolb (1984) and recognises the importance of experience as central to the process of learning. Learning is done by the learner in constructing their knowledge through the transformation of experience. Papert (1993) sees a central role for computers in enabling children to use computers to construct their view of the world. When technology is used in the way described, the technology may enhance the learning by being a cultural amplifier (Bruner, 1966) and a cognitive tool to assist in the transformation of what the students have experienced to a new understanding of their world through the collaborative construction and presentation of their new conceptual knowledge.

This case study demonstrates the interplay between teaching, learning and technology that may enhance learning. Computer enhanced learning for an Information Age can occur in a school that has leadership that enables the integrated use of computers in the curriculum, supports teachers in critically evaluating the use of technology and has policies that support student-centred and teacher-facilitated inquiry learning experiences.

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Acknowledgments

The writers gratefully acknowledge the work of the staff and students of Moonee Ponds Central School. Their inquiring minds and critically reflective practice have enabled this on-going research.
Abstract: Factory Automation Support Technology (FAST) is a new project for Georgia Tech researchers. FAST uses special hardware and performance support software to improve the performance of users on work tasks by giving users the right information, in the right quantity, at the right time. The special hardware is a wearable, voice-activated computer that allows users to operate the system while keeping their hands free to perform their tasks. The performance support software will provide helpful, relevant, just-in-time information that users need to perform their tasks. So, FAST will improve the user’s performance by providing helpful information when and where the user needs it. This paper provides some background information about the FAST system, discusses issues to be addressed by this research, and describes our planned development of proof-of-concept systems in the poultry industry.

Introduction

Today’s workplace is continuously changing. There is increasing automation, down-sizing or right-sizing, and more mobile work forces. The increasing levels of automation require that employees know how to maintain and keep the automation running. More sophisticated automation often requires that the work force be better educated. When organizations down-size or right-size, machines are often used to replace human labor, but fewer employees are available to deal with the more sophisticated equipment. More work has to be done by fewer people. Since automation is often scattered throughout a factory, if not throughout the world, maintainers must travel to the automation to do their work. These mobile workers cannot be supported by current static technologies such as desktop personal computers.

To meet these challenges we need to rethink both technological support and training. This new workplace environment often requires more training which means that training needs to become more efficient. There are several drawbacks to the way training is currently done. These drawbacks are summarized below.

- Training is costly and time-consuming [Gery 1991]. Training takes employees off the job and sometimes requires employees to travel to a different location.

- Training is not immediate [Zemke and Zemke 1995, Gery 1991, Carr 1992]. Training is often forgotten by the time it is finally needed on the job. Also, since a lot of training is not performed in the context of the job, it is difficult for employees to transfer what they are learning in training to the actual job that they do at work [Royer 1979].
• Training is geared towards increasing knowledge as opposed to increasing productivity [Carr 1992]. Since the true business goal of training is to improve the productivity of the work force, training is currently not directly serving this goal.

• Training is trainer-centered as opposed to learner-centered [Connor 1983]. The trainer decides what the employee should know as opposed to the employee asking for the information that the employee needs to get the job done.

• Training is evaluated on learner satisfaction and attainment of classroom goals instead of job performance [Carr 1992]. Good job performance is the true goal of training.

Performance support systems have been promoted as a solution to these training drawbacks [Gery 1991, Stevens and Stevens 1995] [see Table 1]. The goal of performance support systems is to provide employees with the right information, in the right quantity and detail, at the right time [Gery 1991]. This includes just-in-time training in the tasks the employee needs to do. In other words, performance support systems allow less proficient employees to perform as much experience employees. Industry is interested in performance support systems because they not only improve employee performance but also reduce the time normally used for training. Performance support systems train employees as they are performing their jobs, rather than before they perform their jobs. This is a major shift in the way training is currently conducted.

Table 1: Traditional Training versus FAST

<table>
<thead>
<tr>
<th>Traditional Training</th>
<th>Factory Automation Support Technology (FAST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training is not integrated with everyday work environment or shop floor process.</td>
<td>Focus on continual learning process in the work environment; not limited to training; assistance provided at moment of need.</td>
</tr>
<tr>
<td>Training is done before doing the job task being trained.</td>
<td>Training is done while doing the job task being trained.</td>
</tr>
<tr>
<td>Training is focused on increasing knowledge about the job task.</td>
<td>Assistance is provided to improve performance of job task.</td>
</tr>
<tr>
<td>Training is trainer-centered; the responsibility for teaching is on the trainer or training system</td>
<td>Learner is responsible for defining learning goals for getting the job done.</td>
</tr>
<tr>
<td>Assessment of training is based on learner satisfaction and attainment of classroom objectives.</td>
<td>Assessment of assistance is based on job performance.</td>
</tr>
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</table>

The goal of the FAST project is to combine the latest technology in wearable computers with an educational performance support system. The following sections describe the FAST hardware and software in turn. Later sections discuss our research goals and plans for implementation.

FAST Wearable Computer

The FAST hardware consists of a wearable, voice-activated computer system. This computer system was assembled in our lab and is equivalent to a 486 25Mhz desktop computer. This computer system consists of several components [see Figure 1]. These components are described below.

• A see-through display allows the user to work while looking at text, drawings, and video that are pertinent to the user’s job.

• A miniature microphone/earphone provides audio information to the user and accepts voice input from the user which keeps the user’s hands free for job-related tasks.

• A wireless communications link sends and receives up-to-date information to and from the plant computer system.
• A wearable computer allows the user to enter and receive information wherever the user goes.

• A battery pack to supply power for all the components (battery not shown in Figure 1).

This computer system enables employees to get information at the task site and, since their hands are not busy operating the computer, to continue to perform a task as they are receiving the information. This wearable computer system complements software-based performance support systems by making them accessible to employees at all times and in all places during their work day.

We have spent some time looking at the ergonomic issues involved in a wearable computer. For example, where should the computer be worn to keep it out of the way but have it accessible in case the buttons need to be used? We hope that the convenience, comfort, and helpfulness of FAST will encourage employees to want to use the system.

Figure 1: Wearable computer system

FAST Educational Performance Support System

The software component of the FAST system is an educational performance support system. Performance support systems usually consist of several types of information. A typical performance support system provides a combination of the following capabilities [Gery 1991, Reynolds and Araya 1995, Stevens and Stevens 1995]:

• Reference information about a job task or closely related set of tasks
• Just-in-time, task-specific training
• Expert advice about a job task
• Advice on how to use the performance support system effectively
• Application help functions
• Automated tools for task performance
The three most common kinds of support information are: reference information, task-specific training, and expert advice. Reference information describes the task and other related tasks that the employee may need to perform. This reference information supports employees by making immediately available information which they previously had to memorize or look for in a manual. For example, if a quality control inspector in a factory needs to check that a machine reading is within tolerances, these tolerances can be supplied by a performance support system. As a result, the employee does not have to remember the tolerances or to go back to her desk to compare the reading to the specifications in a manual. The reference section not only makes employees more efficient but it also allows them to learn more deeply about a given task. The reference information is always available for the employee to read and provides the theory behind the job tasks it supports.

Just-in-time, task-specific training reduces pre-job training by helping employees to learn while doing their jobs. For example, instead of looking up information in a textbook that was used six months ago in a training class, an employee can, for example, quickly access the on-line procedures for resetting a piece of machinery that has gone out of tolerance limits. This can be done while the employee is standing in front of the piece of machinery. Just-in-time, task-specific training does not take the employee away from the job, so it is not as time-consuming or expensive as traditional training. Since this type of training is done while employees are doing their jobs, it is used immediately in the context of the job at hand. Just-in-time, task-specific training is also geared towards increasing productivity by helping the employees do their jobs as opposed to teaching the employees about their jobs. Finally, this type of training is learner-centered because employees ask for help when they need it to perform a task, and the help gives them the specific information that they request.

Educational performance support systems often contain specific advice on performing job tasks and using the performance support system to its greatest advantage. The advice is usually provided by an expert system. Expert job advice aids employees in reasoning about their tasks. For example, an expert job advisor may help an employee troubleshoot a piece of machinery to determine why it is out of tolerance limits. There can also be expert systems which advise on the use of the performance support system as opposed to the actual job task. An expert performance support system advisor provides information about the performance support system. For instance, when the outcome of a procedure does not match the expected one, the expert performance support system advisor may suggest that the employee use the expert job advisor.

Two other types of information are application help functions and automated tools for task performance. These types of information are most helpful when a supported task involves the use of a computer. For example, application help information can assist an employee with using an application necessary to do his or her job (e.g., a spreadsheet program). Automated tools help an employee perform a high-level task by doing lower-level tasks automatically. For example, an automated tool may aid a quality assurance employee by calculating the average and total of quality data that is entered.

Additional Research Issue

Besides the issues discussed above, an additional issue the FAST project hopes to address is the question of how to support employees with computer technology who do not normally work with computers to complete their tasks. Most performance support systems to date have been designed to aid workers who currently have a computer in their work place and who use that computer to perform their tasks (e.g., airline reservations agents, insurance providers). However, for tasks on which a computer is not currently used, there are other issues to consider. For example, what will be the effect of introducing computers into the job? Will computer literacy be a factor? How do you make the computer an integral part of the system?

Poultry Application

We are currently implementing the FAST concept for two different poultry industry applications. The first application is a proof-of-concept performance support system and wearable computer for quality control inspectors in poultry processing plants. The FAST hardware components will enable quality control inspectors
to directly input inspection data into a computer using voice entry while their hands are busy manipulating poultry products. The software educational performance support system will tell an inspector how to do specific inspections, how to compute measurement averages for the shift, what to do if a measurement exceeds quality standards, and how to notify supervisors if quality standards are not met. The software performance support system will also automatically integrate the quality information into daily reports. We are currently working closely with quality control personnel at a poultry plant in Georgia to develop this proof-of-concept performance support system.

The second application is an initial educational performance support system to aid plant personnel in conducting water reduction audits. The system will allow an employee to walk to various sites inside and outside the poultry facility and perform specific tasks as defined by the performance support system. The performance support system will use text, audio, drawings, and video to show the employee how to measure water flow, adjust water valves, and calculate water usage. We are working with environmental engineers at Georgia Tech who currently perform this task at various sites across the state of Georgia.

Summary

By combining an educational performance support system and wearable computer technology, Factory Automation Support Technology (FAST) addresses the learning needs of workers while they perform their jobs. FAST addresses the drawbacks of current training methods by providing learner-centered training when and where it is needed. FAST is not only addressing training issues but also changes taking place in today’s workplace. These changes include increasing automation, down-sizing, and more mobile work forces. FAST has been implemented as a demonstration system [Najjar, Ockerman, Thompson, and Treanor (in press)] and is currently being implemented in two poultry industry applications.

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Knowledge Awareness: Bridging between Shared Knowledge and Collaboration in Sharlok

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Abstract: Sharlok (SHARing, Linking and lOoking-up Knowledge) has knowledge building and collaborative learning environment through sharing and looking up and linking learners' knowledge. This paper proposes a knowledge awareness (KA) for enhancing collaboration opportunities in this situation. KA plays a role of inducing collaboration by giving the learner the information about other learners' activities within a shared knowledge space. For instance, with messages as "someone is looking at the same knowledge that you are looking at.", "someone changed the knowledge which you have inputted." the learner is induced to collaborate with others who are interested in the same knowledge. The spontaneous collaboration which is created by KA, facilitates to refine and evolve both learners' knowledge and shared knowledge.

1. Introduction

Knowledge acquisition type or open structured CAI systems have been proposed. In such environments, the learner can provide his/her own knowledge into the system. This environment improves and keeps learners' motivation for learning [Yamamoto et al 89a]. Recently, researchers in this area attempt to provide technological support for cooperative and collaborative learning advocated by educational theories like, for example, knowledge building tools and collaborative interface tools. However, few researchers attempt to integrate knowledge building tool with collaborative interface.

We propose a knowledge building and collaborative learning environment, called Sharlok (SHARing, Linking and lOoking-up Knowledge) which integrates knowledge building and collaborative interface tool. The characteristics of this environment are the following:

1. Sharlok allows the learners to share, look up and linking knowledge provided by other learners.
2. Learners can explore in shared hypertextual knowledge space according to their interests. Therefore, users can seamlessly learn to cover the multi-domain, which raises and keeps in a high level their motivation.
3. Both learners' knowledge and shared knowledge space are refined and evolved through iteration of collaboration about the knowledge.

In this environment, it is necessary to bridge between knowledge building and collaboration toward efficient learning.

Researchers in groupware and computer supported cooperative work (CSCW) are investigating how technology can support effectively the interactions between people. One of the elements for increasing communication opportunities is awareness [Dourish et al 92, Bly et al 93, Matsuura et al 95]. In computer supported collaborative learning (CSCL), awareness can be used for enhancing collaborative opportunities. Goldman identified three types of student awareness: social, task, and conceptual [Goldman 92]. These awareness are important for the success of efficient collaboration. Moreover, Gutwin also proposed workspace awareness which is the up-to-the-minute knowledge about other students' interactions within shared workspace [Gutwin et al 95]. However, awareness for the success of collaborative learning in shared knowledge space has not yet been proposed.

We propose knowledge awareness (KA) for enhancing effective collaboration in shared knowledge space. KA plays a role of inducing collaboration by giving the learner the information on other learners' activities in shared knowledge space beyond time and space. For instance, with messages as "someone is looking at the same knowledge that you are looking at." or "another learner changes the knowledge which you have inputted." the learner is induced to collaborate with others who are interested in the same knowledge. In addition, the four types of awareness proposed by Goldman and Gutwin are not provided until the user requests. We call these types "passive awareness". In contrast, we propose "active awareness" in which the system informs awareness to the user automatically.

This paper describes the development of Sharlok and KA in CSCL environment. We first discuss awareness in CSCW
2. Awareness

2.1 Awareness in CSCW

In CSCW, collaboration process is lead from the following processes [Malone et al 94, Kuwana et al 95].

1. Co-presence:
   It gives the feeling that the user is in a shared work space with someone else at the same time.
2. Awareness:
   It is a process where users recognize each other's activities on the premise of co-presence.
3. Communication:
   The user can exchange messages.
4. Collaboration:
   The user collaborates on the specific task with other users and accomplishes the task and common goals.
5. Coordination:
   When we do collaborative work, we sometimes conflict the partners. In that case, a coordination process is needed to resolve the conflict towards effective collaboration.

Researchers in CSCW have already proposed the following awareness, that are implemented using multi-media technologies to bond physically distributed environments.

1. to give information on the surrounding of the target user, e.g., Portholes [Dourish et al 92];
2. to provide common or public space where users can meet, e.g., Media Space [Bly et al 93]; and
3. to simulate informal communicative opportunities in real world using computers, e.g., VENUS [Matsuura et al 95].

2.2 Awareness in CSCL

Awareness is important for effective collaborative learning and it plays a part on how the learning environment creates collaboration opportunities naturally and efficiently. Social awareness provides information on social relationships within the group to carry out the task, e.g., the role in the group. Task awareness shows how the learners accomplish the task. Concept awareness is the awareness of how a particular activity or knowledge fits into the learner's existing knowledge or completes the task. Workspace awareness is the up-to-the-minute knowledge about other learners' interactions within shared knowledge space. In contrast to the four awareness, KA is the information about other learners' activities in shared knowledge space (see table 1).
3. Knowledge Awareness

We divide their activities into (1) "look up", (2) "change", and (3) "discuss". Sharlok monitors and memories of these 3 activities. "Look up" activity means looking up and refer shared knowledge. This awareness provides episodically collaborative chances where the user talks to another learner. "Change" includes creating, updating, and deleting knowledge or links. For instance, by watching this action, Sharlok informs the learner that someone has updated the knowledge her/she offered. If the learner is aware of someone who is discussing about the same knowledge, he/she may join the discussion. By discussing on the changed knowledge, shared knowledge is refined and feedback to the environment.

3.1 Time and Knowledge Proximity

We consider two dimensions of messages for KA: time separation and knowledge separation (see Table 2). Same time type KA informs that other learners are doing something at the same time that the learner who is using the system. This awareness easily mediates the collaboration in real time. Different time type KA provides the encounters beyond time using learners' past actions. Same knowledge type KA is a message on other learners' activities which have relevant to the knowledge that the learner is looking at, discussing on, or changing. This message leads the learner to collaborate with others who are interested in the same knowledge. Different knowledge type KA is an awareness that informs other learners' actions which have no relation with the knowledge that the learner is using. Through this awareness, the learner may be cognizant of unknown but important knowledge.

<table>
<thead>
<tr>
<th>Awareness</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>What should I expect from other members of this group? How will I interact with this group? What role will I take in this group? What roles will the other members of the group assume?</td>
</tr>
<tr>
<td>Task</td>
<td>How does the task fit into what I already know about this topic? What do others know about this topic and task? What tools are needed to complete the task? How much time is required? How much time is available?</td>
</tr>
<tr>
<td>Concept</td>
<td>How does the task fit into what I already know about the concept? What else do I need to find out about this topic? Do I need to revise any of my current ideas in light of this new information? Can I create a hypothesis from my current knowledge to predict the task outcome?</td>
</tr>
<tr>
<td>Workspace</td>
<td>What are the other members of the group doing to complete the task? Where are they? What are they doing? What have they already done?</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Who is discussing the same knowledge that I am looking at now? Who has changed the knowledge since I last looked at it? What knowledge am I discussing now? What knowledge did they change?</td>
</tr>
</tbody>
</table>

Table 1: Types of awareness.

3.2 Passive and Active Knowledge Awareness
From the point of view of providing awareness, we divide KA in "passive awareness" and "active awareness". While, in a passive one, the system does not show awareness information until the learner requests it, in the active awareness, the learner is autonomously informed during his/her interaction with system. Sharlok induces spontaneous collaboration between learners using active awareness. For instance, a learner (Mr. A) can starts to discuss with another learner (Mr. B) using information that Mr. B has updated from the knowledge that Mr. A had provided. Then Mr. A learns from Mr. B. Currently, The default rules of active KA are only same time and same knowledge type. A learner can modify them for his/her own learning style.

4. Sharlok

Sharlok includes shared knowledge space, awareness, and collaboration modules. We developed them using Tcl/Tk, Tcl-DP in a UNIX workstation. The system consists of several clients and a server connected via Internet. Sharlok uses Holmes (Hypertext and semi-Object oriented Learners' MEmory System) as a shared knowledge space. The collaboration is supported by GroupKit [Roseman et al 92].

4.1 Holmes: Shared Knowledge Space

Holmes integrates hypertext and semi-object-oriented database technology. Holmes handles shared knowledge using TRIAS [Yamamoto et al 89b] which allows users to add, delete or change attributes or values at any time during its use. TRIAS represents data with triplets by a small grain size as (object, attribute, value), and it automatically links triplets which have the same element. As in figure 1, search button in the main window opens the browsing window in which the learner can start looking up knowledge. Class button opens the type window in which the learner inputs knowledge. Question button allows the learner to create discussion.

(1) Sharing knowledge:
   Type window shows the class definition and its hierarchy among subjects by tree structured knowledge layer. In this window, a learner can add, delete, or rename attribute or subclass. Using "All Object" button, the system shows all the objects of the selected class into the object list window. By selecting the "New Object" button, a learner can create a new knowledge as an object. The data of Holmes can be not only text but also figure or image.

(2) Looking up knowledge:
   In the Browsing window a learner can look up the knowledge by selecting `object', `attribute' and `value' in turn as in a search condition. Then the system gives the results into the Objects list window and shows the knowledge (object) in the object window such as "physics object" in the figure. The question button in the object window is used for starting collaboration.

(3) Linking knowledge:
   By selecting add explicit link menu in the object window, the learner can link the knowledge (object) as an explicit link. In other hand, TRIAS generates automatically implicit links between triplets. Learners obtain relevant knowledge by "Explicitly linked to/from" and "Implicitly linked to/from" in the window.
4.2 Knowledge Awareness

Using learners' history, KA facilitates encountering other learners not only in real time but also in past time. Sharlok monitors the learners' activities in the shared knowledge space and stores them as learners' history. Passive KA are displayed through fetching the learners' history when the learner requests it. In contrast, active KA are generated according to the rules or conditions. The rules are triggers for the display of messages.

As in figure 2, the same time and different knowledge type KA are autonomously displayed in the message window. The learner can start or join the discussion by selecting "Yes" button. When the learner requests KA by selecting the menu, Sharlok tells him/her the information in "Knowledge Awareness" window. Since KA window shows conference names, their schedules and their participants respectively, the learner can start or join the discussion by selecting a conference name, and see the contents of the discussion using "Content" button.
4.3 Collaboration

Figure 3 shows an example of collaboration in Sharlok. The system displays the conference window when a conference starts. This window shows up-to-minute conference names and their respective participants. By selecting conference name, a learner can join the discussion. The question button in the main window and the object window are used to start collaboration. After a learner selected the button and wrote his/her question, Sharlok calls other learners for the collaboration using their respective message window. If the learner pushes "Yes" button in the window, Sharlok starts up a text tool, a drawing tool and the knowledge (object) for discussion. In the text tool, the only one learner who has the speaking right can write his/her idea. If another learner requests the right to speak his/her opinion and the current writer gives the right, the requesting learner becomes the next writer. In figure 3 a writer is ogata and the next one will be mat. Moreover, participants can use a drawing tool for a discussion. This tool shows their mouse pointers and allows them to draw figures at the same time.
5. Conclusion

In this paper, we described Sharlok which has knowledge building and collaborative learning environment through sharing and looking up and linking learners' knowledge. Through this environment, the learners cover the lack of mutual knowledge each other by sharing their knowledge and they can confirm or correct the knowledge by collaboration. We proposed knowledge awareness (KA) for enhancing collaboration opportunities. That is, KA plays a role of inducing collaboration by giving the learner the information about other learners' activities in shared knowledge space. We believe that KA can bridge between a shared knowledge space and a collaboration well toward efficient collaboration.

References


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The Western Australian Telecentres Network: Enhancing Equity and Access to Education in Rural Communities

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Abstract: This paper describes the activities and operations of the Western Australian Telecentres Network. The Telecentres are small enterprises in rural communities in Western Australia that contain a range of information technology and telecommunication resources to provide members with increased education, training, business and employment opportunities. The Telecentres have emerged from a need to provide increased access to education in the rural regions. They are owned and run by rural communities with small amounts of financial and administrative seeding support from a central government agency. There are now nearly 60 Telecentres in Western Australia and the purpose of this paper is to describe the nature of their operation and activities, to discuss the opportunities they bring to their communities and to consider the viability of Telecentres in general, as independent entities within any rural community.

Introduction

Western Australia is a large state with an area in excess of 2,500,000 square kilometres and a relatively small population of 1.2 million people. While 80% of the population live in the metropolitan area around the capital city Perth, the remainder is widely spread throughout the rural regions. Much of the wealth and prosperity of our State is derived from the rural areas from mining and agriculture. The size and demography of the State and its population provide special problems for the provision of education.

There have been many innovative projects employed among the local educational institutions and organisations to improve the educational opportunities of rural students in Western Australia. Within school education, there is broad use made of audiographics, audioconferencing and telecommunications technologies in support of programs and projects aimed at increasing the scope and number of educational offerings for rural school students [Oliver, 1994]. Among the tertiary institutions, there are a number of applications of computer networks and telecommunication technologies. Edith Cowan University supports its on-campus distance education courses with The Virtual Campus, a computer-based telecommunications network offering access to the University's information technology infrastructure, the Internet and external information services [Watson & Ring, 1994].

More recently the Western Australian Telecentres Network has been established as a means of improving access to, and participation in, post-compulsory education programs among the rural population in general in Western Australia. Today, the WA Telecentres Network is comprised of nearly 60 sites across the depth and breadth of the State. A Telecentre is a community owned and run facility that contains a range of computing and telecommunications technologies including multimedia PC’s, Internet access, telephone connectivity, a facsimile machine, a television, a video-recorder and satellite reception facilities. The Telecentres employ a Coordinator to manage the facility. Community members pay a fee to become members of the Telecentre and are then free to use the facilities for their own purposes. The Coordinator manages the membership, publicises the services available, seeks educational programs appropriate to the needs of the members and facilitates the enrolment of members in these programs. At the same time, the Coordinator provides training and expertise in use of the equipment and markets the Telecentre’s activities to increase income obtained from the services it provides. The Telecentres have been established through the activities of different government agencies at the local, state and national level. At the state level, however, there has been a high degree of well planned and well coordinated activity leading to the development of a structured cooperative community of Telecentres working collaboratively in productive and mutually beneficial ways. The purpose of this paper is to describe the WA
Telecentres Network and to discuss the success of this program in enhancing the educational opportunities in rural regions.

**Background**

In 1991, a review of access and equity in post-compulsory education in rural Western Australia identified a number of impediments to in the participation in and completion of programs among rural students [McGregor & Latchem, 1991]. Principal factors limiting education in these regions included:

- a lack of a culture promoting and encouraging the pursuit of learning and higher study,
- a lack of courses being offered locally to rural students,
- a lack of information in rural areas about educational programs, courses and entry procedures, and
- a lack of study areas.

These problems were evident across all sectors of education, school, TAFE and universities. Potential solutions that were identified included the provision of electronic links for information teaching and learning. The results of this review led to the establishment of the WALINK project which involved the establishment of three Network Centres in the remote north of the State, each linked by television, computer, telephone and facsimile. The Network Centres received seed funding from Government agencies but were established as community resources with a management committee and contingency funding drawn from the local community. Educational institutions within the State cooperated to provide a range of programs and courses making full use of the available facilities. Quickly a small number of other towns in other regions of the State established Centres through the initiatives of the community and joined the project as associate members. This establishment of a cross-sectoral, multi-purpose, community controlled and technologically linked network of learning centres proved to be both viable and flexible. An evaluation of the outcomes of the Project was able to clearly demonstrate its potential and provided a number of recommendations that could aid the successful expansion of a network of this form [McGregor, 1992].

When funding for the original program ceased to flow, the impetus was there to carry the momentum of the project further and today the WA Telecentres Network represents the next stage. Concurrently with the State funded WALINK Project, the Federal Government was supporting a national Telecentres project. Fourteen Telecentres within Western Australia were formed as part of this national initiative of the Department of Primary Industries and Energy. In 1993, as the original funding sources withdrew support, the Department of Employment Vocational Education and Training in Western Australia moved to consolidate the existing network and to take an administrative lead with the promise of funding and support to enable the Project to continue for at least three more years. At this stage, the WATElecentres Network was formally initiated.

It is interesting to compare the development of the WA Telecentres Network with other similar initiatives in other regions in the world. Throughout the early 1990’s, a number of countries established telecottages. Telecottages developed in support of teleworking and telecomputing activities where workers work at a distance to their place of employment using telecommunications technologies [Lyons, Cochrane & Fisher, 1993]. Telecottages were established in town centres on a user-pays basis to provide community members with access to the forms of technology required for teleworking. In order to become financially viable, the telecottages often became small businesses in their own right selling external services based on the technologies that they supported [Griffiths, 1990]. While the telecottages tended to be independent entities, they linked together to form associations to gain the advantages afforded by cooperation and collaboration. Today there are thriving telecottage associations in such regions as Scandinavia, The United Kingdom and North America. Current developments in the expanding Internet and global information superhighway lead many to believe that telecottage organisations and industries will soon experience a significant expansion [Morant, 1993].

**WA Telecentres Network**

While the original WALINK Project Telecentres had many of the features of a telecottage, they differed in several ways. They were not funded entirely from local sources and their activities were strongly geared to the delivery of educational programs. The need for a certain future for the fledgling Network led to an expansion of the original education and training mission to one where it was possible for individual Telecentres to become self sufficient. To that end, the mission of the Project was extended to provide a 'high-tech' infrastructure to stimulate the effective and creative use of telecommunications, computer technology, information access, education, employment, training and business enterprise. Funding was made available through a central Support Unit to aid local communities in the creation of management committees and business plans as part of a bidding process to establish a Telecentre within that community. Communities that were able to demonstrate a sound
plan and need could then receive an initial grant of $30,000 to purchase equipment and to employ a Coordinator on a part-time basis for a year. The local communities themselves were required to sign an undertaking to generate sufficient capital to run the Telecentre and maintain and update its equipment and resources. There were a number of Telecentres within the State that were established by communities who were able to raise sufficient capital from their own sources and thus could operate independently of the central funding agency. Despite their independence, most of these Associate Centres chose to retain strong links with the Telecentres Network cooperating and participating in the central initiatives and activities. Despite different funding agencies and in some cases differing missions, all have formed a close affiliation within the WA Telecentres Network.

Telecentre Activities

Most Telecentres operate in a similar fashion. Community members are urged to become Telecentre members and for a small fee, around $50 per year, are given access to all the facilities in the Telecentre. Many members have particular reasons for joining the Telecentres. Some are university students with no computing facilities but whose courses include access to on-line materials. Such members are able to be trained within the Telecentre and can book the facilities to support their study programs. Others join to make use of particular items such as the fax machines, printer and computer peripherals. More recently members have joined to gain access to the Internet and World Wide Web, an activity of particular interest to rural people.

Each Telecentre is run by a Management Committee made up from members of the local community. This Committee is legally responsible for the Telecentre and its operation. The Committee meet regularly to develop policy, to oversee the operations and to create and plan new activities and projects. The WA Telecentres Support Unit in the city provides an overall framework for planning and implementing programs and projects across all Telecentres. The Support Unit provides training programs for new coordinators, marketing support and continually seeks new functions and tasks for Telecentres. The Telecentres are housed in a variety of locations, usually unused public facilities such as church buildings, courthouses and shire offices. The accommodation is provided by the community and in some instances is not precisely that would have been ordered if choice was available. Most Telecentres are staffed for several hours per day during which time members can come freely and use the facilities. Community volunteers frequently aid in staffing the Telecentres on a roster basis. Outside these hours, access is gained through booking and key access. Most provide 24 hour usage through these means.

The Coordinators identify and publicise the many educational programs which might be undertaken using the facilities of a Telecentre. Such programs include the wide range of interactive television programming conducted expressly by local institutions for the rural communities. The Westlink service within Western Australia broadcasts educational television to remote areas and is received by viewers with appropriate satellite reception dishes. While each Telecentre has a satellite reception dish, so too do 4000 other sites and courses broadcast through these means have a potentially wide viewing audience and market. There are many courses that are delivered through Westlink expressly for students in remote areas with satellite reception facilities. Through the efforts of the Coordinators, enrolments in these customised training programs have increased significantly. At the same time, the Coordinators enrol members of their community in a myriad of open learning and distance education courses acting as agents for many of the national educational institutions. A large number of coordinators plan special educational programs for their own communities based on needs and entrepreneurial opportunities. These activities are used to provide income for the Telecentre. Income is gained from student enrolments in particular courses and from the institutions whose course delivery uses the Telecentre resources. Training courses have been organised for such groups as health professionals, police officers, social workers, small business and farmers.

The Telecentres have a fourfold charter: education, training, communication and employment. In the employment area, a number of initiatives organised by the Support Unit have seen government sponsored employment schemes being used to provide employment in the Telecentres for unemployed members of the community. These initiatives have been particularly fruitful with the employees learning many new skills ranging from information technologies to management and marketing. At the same time, the Telecentres have benefited from the availability of full-time staff to assist with the management and coordination of the Telecentres.

The Impact of Telecentres on Rural Communities

The WA Telecentres have had marked impacts on the communities which they serve. The impacts have been made evident in a number of ways. In the first instance, they have led to a significant increase in the level of post-compulsory training and education. Every student who enrols through the Telecentre in a training program
Measuring the Success of Telecentres

There have been several studies into specific aspects of the Western Australian Telecentres Project and those that preceded it, for example [McGregor, 1992] and [McLoughlin, 1994]. In all instances, findings have been very positive. There has been little evidence to suggest that the intended goals and aims can't or won't be met. In investigating early trials, [McGregor, 1992] found that intended aims were in many cases beyond initial expectations. Several problems were noted but these had more to do with establishing appropriate infrastructure and mechanisms in the agencies that were being supported by the Telecentres. For example, in terms of educational programs, it was suggested that the program providers develop more flexibility in their course planning and delivery to facilitate the provision of courses through these networks. At the same time, it was suggested that the providers place some long term planning into supporting the project to encourage the rural communities to participate more fully. It was suggested that research be conducted into the learning technologies being employed to ensure that program delivery was effective and meeting the needs of the rural students.

[McLoughlin, 1994] investigated the educational technologies being used in program delivery. The majority of programs designed and delivered through the Telecentres are created and produced in the TAFE Media Network and use interactive television as a principal component of the instruction. Interactive television in this context involves one-way video and two-way audio through the use of a toll-free call back number. The talk-back television characteristic of these programs appears to be successful. The investigation by [McLoughlin, 1994] supported this contention and found that students warmed to the interactivity finding it an appealing and effective component of the instruction. This report also reported that other interactive technologies, for example, audioconferencing and computer networks, were positively viewed by students and instructors and seen as important elements of the distance programs. Recommendations from this report included the need for formal training of instructors in appropriate instructional design strategies for the different technologies.

More recently, students have been able to communicate directly with their remote instructors through e-mail and this has provided yet another dimension for the instructional experience. The Telecentres now have full Internet connections providing direct communication links between students and instructors. While these links are used primarily for informal communication, there is the prospect in the future of these technologies becoming integral components of lesson design enabling collaborative and cooperative activities between the remote students as part of their coursework.

While these reports have investigated the educational outcomes and successes of the Telecentres, their move to a more embracing charter led to the commissioning of a further evaluation extending beyond the educational domain. This investigation inquired into the degree to which the Telecentre operations are able to achieve the aims and goals of their plans and mission statements across the broadened platforms of education, training, communication and employment. The most pressing problem for the Telecentres is that of revenue raising and income generation. The original Telecentres were established with educational aims as their sole focus. They were amply funded by Government and local community who saw a need for this type of program. As the Telecentres achieve their aims and provide equity and access to education for the rural communities, the problem upon which their very existence is based tends to diminish. For this reason, the Support Unit and the Telecentres themselves have had to take a more proactive approach to their operation and to see themselves as businesses dispensing services rather than a community service provided free of charge.
The move to a business ethos has been difficult for some Coordinators to embrace. Those Coordinators who have unostentally given of their time as a community service find themselves in a quandary now when confronted with the prospect that their time should not be provided free. Many Coordinators see themselves in the same vein as they view public libraries, as dispensers of information and as a community service. The move to charge for services is a difficult step to take.

Towards Self-Sufficiency

Within the overall Telecentres Network, a current aim is to expand the number of Telecentres to the point where there is provision in every township and community where a need exists. It is also the aim of all individual Telecentres to become self-sufficient within their own communities. Through self-sufficiency, the Telecentres will be able to guarantee a service to their communities that is stable and permanent and will not be withdrawn at the whim of a government. As the Telecentres cement themselves into the communities, the need for permanency and certainty in their futures becomes an important issue.

Observations among the Telecentres in Western Australia suggests that there are a number of variables that can influence their individual self sufficiency prospects. Some of the more important variables include:

- **The Coordinator** It is clear in most Telecentres, the Coordinator plays a very strong role in determining the level of activity and productivity of the organisation. In the first instance, the Coordinator creates the opportunities and encourages the clients to become involved in the Telecentre and in the second instance is able to use his or her own skills in providing relevant services and functions. Telecentres where the Coordinator is multiskilled and brings a business and commercial sense to the day to day operations are those where income generated and cash flow levels are the greatest.

- **Role of the Coordinator** The principal role of the Coordinator in the Telecentre is to act as the manager and administrator of the business functions. This role involves planning and creating opportunities for services and functions that will extend the Telecentre's activity. In Telecentres where most opportunities for income generation is evident, the Coordinators tend to remove themselves from the tedious day to day tasks associated with Telecentre organisation. This has the effect of allowing them more time to attend to the important tasks that demand their entrepreneurial and business skills. In other Telecentres where the Coordinators are more involved with management and client relations, their time is less productively occupied and they have far less time for the tasks that are required to generate and maintain a cash flow.

- **Size of the community** There appears to be a critical mass of potential clients and other service providers in rural communities, under which a Telecentre is likely not to be able to achieve self-sufficiency. In the smaller communities, there is insufficient opportunity for the Telecentre to derive the necessary levels of income required for self-supporting from the narrow income base of the community and its residents.

- **Location of the Telecentre** As with most businesses, the location of the Telecentre is an important factor in determining its profile and level of use. Telecentres that are able to be located in busy locations attract a larger clientele than those where people have to go out of their way to use the facility. At the same time, the size and organisation of the rooms and facilities creates opportunities that are clearly related to income earning potential. If a community wishes to create the best possible prospects for its Telecentre, it is important to give consideration to providing a highly visible location with ample space and room for the sorts of services and activities the Telecentres could embrace.

- **Staffing** The management of the Telecentres involves considerable organisational and management routines of a procedural and routine nature. Access to staffing for these daily routines frees the Coordinators to undertake the more important roles. In communities where there are volunteers and willing workers, the Telecentres are able to operate efficiently and productively. In instances where the Telecentres have few human resources, planning, developing and implementing new programs becomes a difficult task.

- **Productive use of resources** The Telecentres are equipped and resourced with an array of expensive and useful equipment. Those Telecentres that favour an information technology education and training role use their equipment primarily for less productive purposes than those Telecentres where the business enterprise is more favoured. Many Telecentres have discovered a range of uses of the technology that are value adding and result in income generation. Those Telecentres where the technology is used less for value adding activities are those with the least revenue raising from these resources.

- **Strong external links** It is evident that some Telecentres work in relative isolation within their communities while others have created links and connections with external agencies and bodies. The activities of the Support Unit help in marketing the services and activities of the Telecentres as a group but increased opportunities are evident in instances when the individual Telecentres create their own links with...
external groups. The Telecentres have also forged other links by operating in small clusters among themselves based on geographical location to provide training and support services.

- **Active Management Committee**
  All Telecentres in Western Australia are directed by a management committee whose role is to provide direction and guidance to the Coordinator. In some instances, the management committees are extremely active in their role and play a large part in determining the functions of the Telecentre. Others are content to oversee and administer and to leave the details of running the Telecentres to the paid Coordinators. It is evident that in instances where the management committees are proactive and supportive, that the Telecentres have increased opportunity for enterprise and commercial activities, a critical component of developing self-sufficiency.

Despite the early reliance on external funding and support, most Telecentres within the WA Network are relatively confident that they will be able to become self-funding and self-sufficient. Their confidence and optimism is based on the large part that Telecentres have come to play in the rural communities and the increased opportunities that have emerged from their activities. Although most Telecentres still see their principal contribution to the community as being providers and facilitators of education and training, they see their business and commercial ventures as appropriate and capable means to support these goals.

### Summary and Conclusions

Telecentres are the forms of institution and organisation that would be of benefit to rural communities in any region in the world. Already there are forms of Telecentres in many countries. The Western Australian experience is a unique example of Telecentre operations. This operation has evolved from early days when a distinct educational aim guided all activities to the current stage where a fourfold charter of education, training, communication and employment has provided a stable infrastructure supporting a drive for self-sufficiency and self-determination. Important components in bringing the network to its current form has been the role of a Central Support Unit and the close collaboration of all Telecentres in a larger network. This Network is now in a strong position considering expansion to further communities in the State as well as consolidation of existing centres. The activities and operation of the WA Telecentres Network provides a sound model for rural communities throughout the world seeking to improve access and equity for their participants to education and training through use of telecommunications and instructional technologies.

### References

"Hypermedia and the transfer of self-directed learning"

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Abstract: The idea of self-directed learning has been one of the main interests of the past few years. The possibility of increasing the level of self-directedness in learning by using technology-based learning environments is one of the interests in the research field of computer-based learning. We want to present in this paper some theoretical and practical considerations as well as empirical results which have aroused in one educational development project concerning the problem. We are approaching the theoretical problems from a real-life context: the discussion of the subject arouse from an organization, which aims to improve their training programs and begins to emphasize the idea of self-study.

Introduction

In this paper we want to discuss the theoretical and practical problems of developing learning environments from the view of constructive conception of learning. We will focus on the constructive concepts of self-directed learning and transfer in learning. The purpose is to gather the matters and circumstances that affect the possibility of arranging instructional settings by using hypermedia that could increase the transfer of self-directed learning. We have two special aims in our work:

- to support "traditional" transfer: what is learned in learning situation is implemented in working situation
- to support self-directed learning attitude and habit: If one needs to learn something then one is willing to do it by oneself using appropriate learning environment. During the academic year 1995-1996 we will test our model. First empirical results of our research should be available in May 1996.

The study concerned is implemented in one of the leading telecommunication companies in the world. The business area in which the company operates is cellular network systems. Because of the huge growth of the cellular networks in telecommunication business in the few last years, the company is recruiting hundreds of new workers yearly. As a consequence of the growth, there is a pressure to train the newcomers to their assignments and to be part of the culture of the company efficiently and quickly. The area of the company's business is well focused and requires a lot of expertise and professionals. That is the reason why they have to teach the newcomers by using their own staff.

The trainers are overloaded with the training and that is the reason why the company has decided to start projects in order to improve the training program. The training in the company is mainly technical courses and the trainers have only little knowledge and education about learning and instruction. Mostly the courses are designed and delivered "traditionally"; the trainer speaks and the students listen. The trainers do not use any exercises or tests to analyze if the learners have learned anything. The evaluation of the training mainly measures the actions of the trainer.

In this project, the research team in Hypermedia laboratory of Tampere University, has a task to build the basis for the development of the training. The main focus will be in the usage of the self-study materials as a part of the training. The first step will be training the trainers to become authors of their own computer-based courseware. As a part of the training, they will be introduced to the facts how to benefit from using self-study materials in their courses. The trainers will get a template of a program which is based on the basic ideas of
how people learn and how simple computer-based learning material should be constructed from the our point of view.

Self-directed learning from the constructive point of view

The idea behind the project is based on the constructive conception of learning. The main factors in constructive learning is that human learning process is individual and goal-directed. People use their current knowledge to construct new knowledge. The learning is always situated. The human memory capacity is very low, so we are able to process only limited amount of knowledge at the time. (e.g. Resnick 1989). One important issue, when improving the learning process, is to pay attention to the meaningfulness of the learning situation. If the learning situation is meaningful, it will increase the quality and effectiveness of learning.

There are many theoretical explanations for the concept of self-directed learning, one of the most familiar ones are the andragogical explanations (e.g. Knowles 1975, Mezirow 1985). Knowles sees the education two-dimensional, one end is the self-directed learning and the other end is teacher-directed learning. According to Knowles (1975,18):

"In its broadest meaning, 'self-directed learning' describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes."

Mezirow emphasizes the meaning of critical thinking in self-directed learning. He points out that

"Becoming critically aware of what has been taken for granted about one's learning is the key to self-directness". (Mezirow 1985).

Our approach to the concept of self-direction is constructivist. One important view of the basic ideas of constructive learning is that it is in itself in a way a case of self-directed learning (e.g. Simons 1992). The constructive conception of learning is learner-centered, and it emphasizes the internal learning process, even though the concept of self-directed learning is seldom mentioned when discussing about constructive learning. The basis of constructivist self-directed learning is the idea that the learner sets the goal for his learning and evaluates the learning process and achieving the goal by himself.

In a way only learners can be active participants in the learning process, when you emphasize the meaning of the internal learning process. The result of the learning depends mostly on the activity of the learner. The instructional settings can strengthen the effectiveness of the learning process. When designing the learning environments it is important to stress the meaning of the feedback that the learner receives from his learning. The most important is how the learner analyses the feedback. The feedback has essential role in the learning process, particularly when the goal of the training is in developing the learner's learning process.

In the constructive concept of self-directed learning, the evaluation of the results of the training is the key element. Evaluation from a constructive perspective should be more of a self-analysis and metacognitive tool (Jonassen et al 1993, 243). Self-evaluation is also something that needs to be taught, we seldom are able to analyze our actions until we are taught how to do it.

It is not obvious that the learner can analyze the feedback or set goals for his learning, self-direction is a characteristic that needs to be taught at first. The concept of self-direction can be seen as an instructional method (self-directed learning) or as a personality characteristics (learner self-direction) (Brockett & Hiemstra 1991,18). The way we learn is part of our personality, and we all know how hard is to change qualities of personality. Trying to change the way we are used to learn is a very complex and time-taking process. We are often used to the idea that the teacher knows everything what we need to know and how we need to learn. We don't have to have the responsibility of our learning or of the goals of our learning. Self-directed learning as an instructional method means that the idea of increasing the level of self-directness of the learner's is one goal behind the instructional design.
Constructivism, Hypermedia and The Holy Grail of Educators - Transfer

Transfer as it has been seen

In a broader sense, the older research on transfer agrees in speaking of transfer that if something learned in one context is transferred onto another context. In the more recent research on transfer the concept of transfer is applied if a learning process has taken place in one context (the source) and if the learner is subsequently confronted to a task or problem in another context (the target) whereby an application of the learned content is meaningful. By means of the distinction between source and the target the concept of transfer acquires a specific, scientifically workable meaning.

The four possible transfer could be classified:

a) The competence acquired in the learning context reveals to have impeding or disturbing effect in the functional context = negative transfer

b) In that case no transfer between the source and the target take place: there is zero transfer

c) The individual uses the competence acquired in the learning context. That situational transfer could be defined as lateral or horizontal transfer.

d) The competence acquired in the learning context enables the individual teacher not just use correctly applications, but even a further enhancement of competence in the sense of a successive additional learning. This could be called vertical transfer.

A major feature of the grails myth is, in Resnicks (1991) opinion that skills and knowledge are represented in a person, independent of the contexts in which they have been acquired, thus enabling the person to apply acquired knowledge regardless of the situation. This conception has been challenged by researchers who support constructivist position. Their approach focuses on the idea of situated or contextualized cognition.

Constructivistic Concept about Transfer

One main characteristic of traditional transfer paradigm is distinction between learning application. This approach has allowed experimental approach but at the same time it has denied interaction between the source and the target. According to the constructivist position, construction occurs within both learning and application situations. The construction process in turn affects learning processes within both situations.

Messner (1978) has designed constructivist transfer model: In his model learning is the construction of a (cognitive) structure. Application (transfer) is reconstruction of a structure. Reconstruction distinguishes between familiar versus novel conditions and in unchanged versus changed form.

The reconstruction of a structure is effected:

<table>
<thead>
<tr>
<th>in unchanged form</th>
<th>under familiar conditions</th>
<th>reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>in changed form</td>
<td>under novel conditions</td>
<td>transformation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>application (transfer)</td>
</tr>
</tbody>
</table>

Table 1: Categorization schema for transfer (Messner, 1978, p. 53)

Messner's thinking provides a basis for discussing theoretical aspects of the constructivist approach as transfer of learning is concerned.
Creating hypermedia based learning environments to support transfer

Hypermedia is a combination of hypertext and multimedia. Hypermedia based learning environment could be extremely versatile and effective. Hypermedia could provide some new elements for instructional design. From the constructivist point Bransford et al (1990; 1991) has proposed the following instructional arrangement to support transfer:

- situating learning in order to relate knowledge to action, to create a significant and problem-oriented context, to initiate active engagements, and to support understanding;
- emphasizing application context in order to define both potential and non-potential application contexts;
- Examining the subject matter from multiple points of view in order to effect more flexible knowledge and knowledge access;
- Decontextualizing in order to include different examples, to bridge domains, and to foster abstraction.

The concept of anchored instruction presents the learner with authentic problem contexts which define a range of application. There has been three other possible approach to support transfer from learning to actual working situation:

Greeno (1989) and Kintsch (1990) propose that abstract, symbolic computation cannot be made to relate more to reality. One possibility to make these abstract computational models more concrete is use the possibilities of simulations which clarify the connections which prevail between the symbolic level and reality.

Cognitive apprenticeship idea is based on novel and expert research. It has been found that experts in their activities always apply situated thinking strategies (Brown, 1990). In this way, the experts defines and demonstrates examples for knowledge application.

The final approach is concerned with advanced construction of knowledge within ill-structured knowledge domains. The problem addressed is that of learners who construct knowledge which they cannot apply to new problems. Central to transfer in these cases the principle of multiple juxtapositions of instructional content... revisiting the same material, at different times, in rearranged contexts, for different purpose, and from different conceptual perspectives (Spiro et al., 1991, p. 28).

Challenges in developing courseware that supports the transfer of self-directed learning

When one defines self-directed learning as an instructional method and try affect to the transfer of it in a hypermedia-based learning environment, there are a few following challenges to be faced.

In improving the training, as a mean of increasing the level of the self-directedness of the learner, one has to approach the problem widely. Often the software applications fail because of the lack of knowledge about the wider organizational context in which the technology is inserted. There are huge differences in organizational structures and cultures which can explain different ways in which technology is used in organizational settings. Training organizations and enterprises are bearers of culture, values and goals. (Zucchermaglio 1993).

It is also important to find the way how to support and motivate the usage of self-study materials. It could also be recommendable to analyze the concept of work and the definition of the assignment in the organization concerned. Studying and finding information independently could be defined as a part of the whole assignment. The training organization may have to change their view of teaching and learning. The goal of the whole training system might be described as to create learning environments, where the 'traditional training' and technology based instruction are parts of the whole learning environment.
One challenge is changing in the idea of evaluation. It is common to evaluate training by evaluating the trainer's actions and the way he teaches. However, in the constructive conception of learning, the main issue is the learning process of the learner. The goal of the training should be in teaching the learner learn the issue concerned and improving his learning process. It is too often the case, that a technical approach based only on computer science and engineering cannot provide the right solution for efficient learning and use of new technology in workplaces. We should use the ideas of the cognitive science of instruction as a guide in designing cognitive based technology that really improves and sustains efficient social learning in schools and in industry. (Zucchermaglio 1993). "Our theory of learning is implicit in our design, and hence one can come to a reasonable understanding of our beliefs about learning from an analysis of that design" (Duffy & Jonassen, 1992, 1).

What could hypermedia provide for the transfer of self-directed learning?
The constructivist approach allows individuals first learn how to handle problems in specific contexts. The second goal in these approaches is to overcome narrow contextualization. This goal corresponds to the issue of transfer. Hypermedia provides some elements that could help both increase learners situated knowledge and self-direction as well as transfer that knowledge in new situations. Those elements are interactivity; anchored, authentic problems, real time simulations and possibilities of expert modelling.

The holy grail of educators - challenge of transfer is still there. Constructivist perspective to it will offer one extremely interesting theoretical approach to attack to this challenge. Hypermedia as a learning environment and instructional intervention might provide some new possibilities to understand that very complex phenomena.

References


Distributed Computing Network for Science and Math Education in Rural New Mexico

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Abstract: This paper describes the TOPS (Teacher Opportunities to Promote Science) and TOPS Mentor programs, which focus on telecommunications and science, math, and technology content. The backbone of these programs is GeoNet, an electronic bulletin board system set up and maintained at Los Alamos National Laboratory. The TOPS experience exposes teachers to science and math in the context of a real problem of genuine scientific interest, increases their knowledge of science and math, enhances their teaching skills, provides activities for their students, and increases student and teacher abilities to communicate with other teachers and scientists. Their students, in turn, learn to approach scientific problems with enthusiasm and confidence. They perceive the beauty and joy of scientific endeavor and develop self-assurance, persistence, and enthusiasm.

Introduction

The Teacher Opportunities to Promote Science (TOPS) program promotes excellence in the teaching of middle school science and math; interests the students of participating teachers in science, mathematics, advanced technology, and advanced communication; and creates new avenues for teachers and their students to learn and retain new math and science skills, use telecommunications, develop and build scientific equipment, and collaborate with other classes throughout the state. The TOPS program is sponsored by Los Alamos National Laboratory (LANL) and Sandia National Laboratories, and enrolls 50 middle school teachers from New Mexico for three years. Two cohorts of teachers have completed the program; the third cohort is nearing the end of the program and we are beginning to recruit a fourth. The intensive, multi-year TOPS Mentor Program, sponsored by Los Alamos National Laboratory, includes fifteen master middle school teachers from all areas of New Mexico who have already completed the TOPS program. The experienced teachers who participated in the Ring of Light project act as mentors and advisors to the new TOPS teachers. This allows for the free exchange of ideas, relieves the feelings of isolation that many experience, and improves expertise on both sides. Both programs enlist teachers and their students to gather information about the weather and other environmental data, to use those data to study the dynamics of storms, and to contribute the data and results to others studying atmospheric statics and dynamics. Having students participate in experiments of genuine scientific interest creates a motivation to learn science and the underlying mathematics, and to become more proficient in the use of technology and telecommunications. Students and their teachers gather weather data and other environmental data; propose, design, execute, and analyze their own experiments; and design and build their own detectors as needed.
The backbone of these and other possible projects is the capability for instant communication provided by GeoNet, a bulletin board system (BBS) set up and maintained by LANL. GeoNet connects geographically remote schools with each other and with Laboratory scientists, allowing the free exchange of ideas, techniques, and solutions, regardless of how geographically isolated a school may be. Because many of our schools have limited access to resources, GeoNet is relatively low-tech. This enables every participating school district, school, teacher, and student to take advantage of GeoNet for telecommunications. Different levels of technology are available to accommodate those few schools that have direct internet access and are able to participate on a more technologically advanced level. We have recently upgraded GeoNet to provide limited line access to the internet and to global E-mail.

It is crucial for teachers to be knowledgeable and experienced enough to be capable of fostering their students' interest in science and math. Both TOPS projects provide equipment, computer network support, training, and other assistance, and develop a discovery-based, intercurricular physical science and mathematics program. Through this support, teachers are given broader experience in science and technology, which they can then share with their students. The projects use a modular, hands-on approach to learning. Because students usually decide whether to continue studying math and science during middle school, but need support and encouragement in high school, the program includes grades 6–12, with a strong emphasis on the middle grades.

The TOPS teachers and Mentors have arranged themselves into regional groups that meet frequently and provide mutual support. Academic year and summer workshops for the teachers and for highly motivated students provide instruction, training, and assistance with the materials, activities, and information necessary for targeted experiments.

Ring of Light and Storm Tracking

The TOPS programs build and expand on the experience of the highly successful Ring of Light Project. Ring of Light was established around the May 10, 1994, annular solar eclipse. During an eclipse, the moon's shadow travels at supersonic speeds through the atmosphere and creates substantial localized temperature variations. Theoretical work [Chimonas and Hines, 1970], [Chimonas and Hines, 1971] has shown that a bow or shock wave should be associated with the supersonic passage of the shadow spot. Ring of Light measured, for the first time, surface barometric pressure variations, wind speed and direction, temperature, and insolation over a large distributed array of sensors in and around the path of annularity.

We recruited nearly 50 middle school teachers and their classes throughout New Mexico to operate weather stations and log data during and around the time of the eclipse. Most science classes used a connection to the GeoNet BBS at Los Alamos to enter data, analyze their findings, and exchange information. After the eclipse, teachers who were also in the TOPS program began preliminary data reduction and analysis. Those preliminary searches indicate that we may have indeed detected the predicted bow wave.

The students and teachers found that participating in a real experiment (that had genuine scientific interest) to be one of the most exciting aspects of Ring of Light. We wanted to maintain that excitement. We discovered that the modeling of ground friction is a major problem in predicting weather. Because meteorologists now rely heavily on satellite data for weather monitoring and prediction, there are few ground-based sources of data available to modellers. Data from those sources are typically averaged over 15 minutes, so any fine structure in the measured values is not detectable. Difficulties in properly modeling the travel of air masses over different kinds of terrain further exacerbate the problems we encounter from the dearth of ground-based data sources. New Mexico, with its wide variety of topography and vegetative cover, including mountains, plains, canyons, mesas, forest, and desert, is ideally situated as a laboratory for storm tracking.

Through the TOPS programs, teachers and their students learn how to gather valid data, and develop techniques to deal with and analyze those data. Field techniques require familiarity with the equipment, how it works, and how to fix simple problems. Analysis requires many skills, including classifying, comparing, estimating, planning, developing ideas, testing hypotheses, making models, exploring, and discovering. Teachers and their students learn how to use computers and networks as tools in all those activities. They explore how to find and understand patterns, proportional relationships, and generalization. They have been (and continue to be) exposed to the limits of measurement. Computer networks already make significant amounts of data freely available to the public about environmental factors such as rainfall, insolation, temperature, barometric pressure, and so on. Participants in this program are able to contribute their own data to local, state, and national databases, and to understand how their location fits into the national picture. Participants in our programs learn...
methods of communication, including the making and use of plots and figures, graphs, tables, models, and charts. Teachers and their students use GeoNet to exchange information between schools, and to provide information to other teachers, students, and parents in a compact, coherent, and understandable way.

GeoNet

Participating teachers and their students share data and communications through GeoNet, a BBS designed and administered at LANL. We used a commercial information management tool, TBBS 2.3 by eSoft, Inc., to create and compile the GeoNet software. The program maintains a system of menus which teachers can navigate to transfer data, read informative files, post public messages, send private mail on the local system and out to the internet, explore internet sites and converse in real-time chat sessions.

GeoNet is a dedicated program that runs on an Intel 486 machine on top of the DOS operating system and uses 12 MB of RAM to give teachers a quick response. While the system itself must run on a fairly powerful computer, teachers can connect to it with simple machines, such as a Mac Plus or an Intel 8088. The minimum requirements are a phone line, a modem, and a basic computer running telecommunications software. Those turn the remote computer into a terminal for GeoNet.

Participants access GeoNet either by dialing up via serial communications protocols and a phone line, or by telnetting to the system using IP (the internet protocol) and a line connected to the internet. Teachers can send internet mail and access any file on the system regardless of their connection method and protocol. Those who dial up to GeoNet can send and receive internet mail, and those who telnet to GeoNet via the internet can send and receive mail local to the bulletin board. In addition, teachers who dial up to GeoNet using serial communications can telnet out of the system to internet sites using IP.

To orchestrate and synchronize these very different communications protocols (serial and IP), two additional computers are necessary. The first is another Intel-based 486 machine, called the IPAD (Internet Protocol Adapter), which literally becomes a protocol interpreter for all three machines in the system. It is available commercially from eSoft, Inc. The second is a Novell network fileserver which stores files that can be accessed by the DOS machine running GeoNet and by the IPAD. The network server introduces another communication protocol, the Novell protocol IPX. The coordination among these three computers is instantaneous and seamless. GeoNet users always see the same menu system and follow the same procedures for sending mail and viewing files regardless of their connection method and protocol.

Following the path of internet mail and a data file illustrates the roles of the three computers that comprise the GeoNet system. A teacher dials up to GeoNet and enters a private message with an internet mail address. The DOS machine sends that message to the network fileserver. The IPAD regularly checks for new mail on the fileserver and, when it finds a message, sends the mail to the internet. Similarly, a teacher may dial up to GeoNet and need a data file that has been transferred to the system through the IPAD by a teacher using the internet. The data file is stored on the network fileserver. When the teacher downloads the data, the GeoNet DOS machine retrieves the file from the fileserver and transmits it over the modem. The receiving teacher is unaware of the location and origin of the file but receives it successfully.

Instructional Component

The Science Education and Outreach groups at Los Alamos and Sandia National Laboratories conduct the TOPS programs. The TOPS programs are conduits between the Laboratories and classrooms. They bring the unique resources of a national laboratory: teams of world-class research personnel; complex research projects; and state-of-the-art facilities and technologies, into the classroom to help meet the instructional needs of science, math, and technology teachers and their students as identified in [AAAS 1993] and by local and regional needs assessments. Specialists in science education designed and continue to improve the programs to provide a conceptual bridge between the classroom and the science at the Laboratories. Education specialists work with scientists to identify those salient pieces of science content and the research process that are key to student learning and understanding. Scientists and education specialists collaborate to design and implement an instructional model based on national standards and accepted best practices and on exciting, current scientific research.
Teachers are immersed in Laboratory science through site visits and field trips, and by working directly with scientists on research projects. Laboratory-sponsored experiments provide an immersion experience for the yearly TOPS Summer Institute and follow the Pacific Northwest Laboratory (PNL) immersion model based on the four-step instructional model developed and described by [Loucks-Horsley et al. 1990]. The emphasis is on using scientific tools, methods, and processes.

The programs provide participants with experience in curriculum development, designing assessment consistent with inquiry based learning, and integrating technology and a computer network support system into their curricula. We present several exemplary instructional models to the teachers. These include: the constructivist model [Yager 1991]; Russell Wright's “Event Based Science” curriculum (developed through a grant from the National Science Foundation); Microcosmos [Zook 1992]; and the “Interlearn,” the integrative learning model by Laurence Martel of the National Academy of Integrative Learning, Inc. Teachers integrate these models into curricular units of their own design that they then implement in their own classrooms.

Participating teachers develop hands-on, investigative activities using weather data and other environmental data. Those activities confront their students with the problems and challenges of collecting and dealing with data, and with the problems and challenges of our global environment. Classes and individuals are encouraged to develop, propose, and execute their own investigations using the collective data, and to disseminate their discoveries. For example, classes have proposed and begun insolation studies, discussed energy alternatives, and studied passive solar techniques. Others have characterized our commercially available Davis Weather Monitor II™ stations and LANL-designed insolation devices at a meteorological station at Sandia National Laboratories, or used filters to study the insolation detector frequency response. Teachers, students, scientists, and engineers collaborate on these and other studies. Classes also participate in several experiments initiated by Laboratory and other scientists such as the characterization of weather patterns in New Mexico and tracking storms as they travel across the state. When appropriate, Laboratory scientists help participants develop, design, and build new detectors, and incorporate those new data into studies. For example, Laboratory scientists have developed and designed a simple lightning sensor, with a sensitive radius of about 100 kilometers. This sensor is simple to build; teachers and their classes are beginning to assemble these detectors and use them to characterize some lightning patterns during New Mexico's spring/summer thunderstorm season.

Integration of science and math curricula is another goal of the program. We encourage teams of teachers to participate in the program, either at a single school or in a given district. Preferably a team has at least a math and a science teacher. Even when only one teacher in a given school participates, we have had success in enlisting the aid of other teachers at that school in modifying curricula, incorporating the weather and environmental experiments into classes, and encouraging students to participate. Teachers have arranged themselves into geographically close regional groups that meet in addition to the regular meetings and workshops, to help foster communication and cooperation. Laboratory scientists and education specialists attend those meetings as well. We have found that the math/science integration also promotes coordination and incorporation between other areas. For example, traditional Native American responses to the May 10 eclipse increased cultural awareness: we found there were cultural concerns in a science event and were able to explore those. The total immersion in one particular topic encouraged by these programs thus expands into other areas of study.

Evaluation

Formative and summative evaluation are an integral part of the TOPS programs. TOPS has piloted several evaluation tools for the National Center for the Improvement of Science Education, including a template for the evaluation of national teacher enhancement programs and a teacher impact survey. TOPS, in partnership with a cognitive psychologist at the University of New Mexico, has completed a study on the use of concept mapping to assess the structural knowledge of middle school science students. We are currently researching the impact of the TOPS programs on students. We conduct implementation and process evaluation for each planned activity such as a workshop. The majority of the questions focus on what teacher participants have learned and whether they are making progress in transferring their new knowledge to their classrooms.
Conclusions

A program that promotes excellence in the teaching of math and science while increasing enthusiasm and confidence in the learning of math and science can be a reality. The successes of the TOPS and TOPS Mentor programs are a testament to this. We find three elements are vital to such a program: incorporating a real experiment of genuine scientific interest to establish a base of curiosity and purpose; a multi-year program with support from education specialists, scientists, and engineers to provide a sound instructional model and a scientific base of information; and ongoing communication and support between the teachers, students, education specialists, and scientists to sustain enthusiasm and growth.

References


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Developing the Virtual Campus Environment

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Abstract: A Virtual Campus Environment is under development based on an object-oriented model of the actors involved in the different processes of Computer Assisted Distance Learning. This paper describes the preliminary architecture of the Virtual Campus Environment that will be provided to the actors to support their interaction. It then focuses on the development of the Scenario Editor, a central component that provides the main user interface to the learner, the trainer or the designer, and also gives access to the other assistance, consultation and collaboration tools within the environment.

The challenge facing TeleLearning and Distance Education today is to favor the autonomous knowledge building process by the learner, while at the same time, fully supporting the very important collaborative dimension of learning. This challenge cannot be met without information technology and without the integration of all the useful technologies in a coherent architecture. We call such an architecture the Virtual Campus.

The Virtual Campus: an integrative concept for training and research

The Virtual Campus has become a powerful integrative concept at Télé-université. An ambitious plan has been tabled to the Ministry of Education to transform the 22 year old distance university into a virtual campus based on an interesting merge of knowledge-based, hypermedia and telecommunications technologies.

Since 1991, the Cognitive Computing and Training Environments Research Center (LICEF) is involved in the development of such a Virtual Campus Environment (VCE), covering the whole distance learning process, from analysis and design, to development, production, management and maintenance of Computer Assisted Distance Learning systems. This process is now the integration framework of most of the research being conducted in our research center.

- From 1991 to 1993, a three year project [Paquette et al, 1993] has resulted in the definition of an integrated technology-based TeleTraining model. On this basis, a first VCE using low-level technologies widely available has been developed, tested and delivered for one of the courses at Télé-université. This environment has demonstrated the feasibility of the concepts presented here since it is actually used by a hundred students in a real life context, within one of the university's regular programs.
- A LICEF team has been also working at the design of teleconferencing environments and analyzing their content using a system called ACTIA [Ricciardi-Rigault and Henri, 1994]. This system is an important part of a collaborative distance learning environment. It uses a linguistic analyzer to model the content and the interaction in a teleconference. The goal is to develop tools to help learners and trainers find useful information in the messages, and to provide them with a diagnosis of the interaction.
- Another team has explored the question of editing and accessing a distributed multimedia document base [Bourdeau et al, 1994]. A distributed catalog system gives access to text, sound and video documents, distributed on different microcomputers on an heterogeneous network. The system proposes different modalities for real time consultation or transfer of documents, depending on the transmission speed available on the network. A pedagogic scenario including numerous consultation and transfer activities has been designed and experimented to validate this component.
- Since the beginning of 1993, LICEF has undertaken the development of a didactic engineering workbench [Paquette et al, 1994]. The workbench can be used in any delivery modes: classroom, self training, task integrated training and distance learning. It can also integrate any pedagogic strategy or media. In December 1994, an experimental task support system based on knowledge modeling has been made available for instructional designers. It also embeds an
intelligent advisor using pedagogic expertise to help designers analyze the learning context and needs, to build a model of the content and to assign it to learning events, to choose the strategies and the media, to define the learning instruments and to finally plan the development of the learning system.

- LICEF has also developed a first version of a tool called ÉpiTalk [Pachet et al, 1994] that enables a designer to add an advisor system to an existing application. This system has been used to build the Didactic engineering workbench's advisor system, together with another advisor for a scientific discovery application. ÉpiTalk provides the designer with a graphic interface to specify his view of the application in the form of a task tree, to define computer objects to capture the interaction of the users with the application and to generate advisor agents. Each of these agents has a private rule base that can trigger advises when certain trace conditions are met. Another interface enables the designer to define the rules which embed expertise in the application's knowledge domain.

These projects are all possible components of a Virtual Campus Environment. Since the end of 1993, we have started working at their integration into a coherent framework. The project reported here is part of a major joint venture with industrial partners on Telecommunications multimedia and their applications to education and training. The technological development includes a video-codec and an ATM platform that together allow multipoints multimedia communications. With three industrial partners, we are in the process of building a library of distance learning tools based on this platform, serving as building blocks for the Virtual Campus.

Summary of the Virtual Campus Model

In (Paquette et al, 1995), we have described the methodology used to build a model of the Virtual Campus. We will summarize here the method and identify some of the results on which the VCE architecture is based.

Actors and roles
The actors represent everything that interact and exchange information in the system: persons, pieces of software or documents. Some are information transmitters while other are receivers. Most are sometime transmitters, sometimes receivers. According to Jacobson's Use Cases Methodology (Jacobson, 1993), the actors are essentially defined by their roles, that is by the way they interact with other actors into processes. In the Virtual Campus, we have distinguished five actor categories: learner, trainer, content-expert, manager and designer, each defined by a precise set of roles within the Virtual Campus.

Roles and processes
Each of an actor’s role can be seen as a group of processes or utilization cases that an actor can execute. Each process is a set of actions or operations that a user can perform while interacting within the Virtual Campus. A process is one of the ways to use the system. The set of all processes define what the system is used for, why it is developed, what are the different ways to use the system.

For example, one of the learner’s role is to act as a Navigator, that is to circulate through the learning activities, medias and tools of a pedagogic scenario to achieve some learning objectives. Here are some of the processes involved.

- The navigator accesses the scenario displaying the activities in a learning unit (or the learning units in a course, or the courses in a curriculum)
- If the navigator sees a course scenario, he can select one of the learning unit and open its own scenario where the activities are displayed
- The navigator finally selects an activity he wants to explore or achieve. When he opens the activity, the system verifies if the scenario constraints such as prerequisite activities, are respected.
- If no constraint are violated, the inputs, for example documents to consult or tools to use, the output, for example production to make, and the assignment for the activity are presented to the learner.
- When adopting the Decision-maker role of the manager-actor, the learner (or the team) will define its own personalized scenario by adapting the scenario proposed by the designer-actor.
- The system will keep a trace of the learner's interaction with the environment for the interactive advisor and to facilitate diagnosis by the trainer-actor.

1 The Télécommunications multimédia project is funded by the Technology Development Fund of the Government of Quebec.
Object description for role processes
Each of the description of the processes defining a role (such as the navigator role) is a preliminary step to the
classification of the objects involved in the processes. Using a methodology such as OMT, the object modeling
technique (Rumbaugh & al., 1993), one can then represent graphically the objects involved in each of the
processes. For example, this is the step where the scenario will be defined as composed of learning events,
documents and tools with links between them.

Functional analysis
Finally, a functional analysis phase provides a detailed description of the environment with its collection of
interrelated tools. A format has been established for specifying functionalities of each tool; it includes the
objectives of the tool, the Use Cases to which it refers, the dependencies, and the relations with other tools. The
collection of these tools within the VCE has still to be stabilized but it already includes advanced communication
tools such as video conferencing, groupware, white board, screen and application sharing, and intelligent tools
such as trace analysis and interpretation for advice.

The general architecture
The following figure present the general architecture of the Virtual Campus Environment (VCE) based on the
model of the Virtual Campus. The VCE is designed for a user that can be any actor on the Virtual Campus.
Differences between actors will appear at lower levels when particular ways to use the sub-environments will be
defined. These sub-environments are shown by the « is-a-view-of » links on the figure. They correspond to
general functions in the Virtual Campus such as the network of activities (learning scenario), the collaboration
space, the media consultation space, and the user’s assistance space or component.

At the heart of the architecture is the Learning Scenario component that provides many possible work plans to
the user. The learning scenario is the common point of reference and the subject of collaboration between the
different actors. It is basically a network of Learning events (curriculum, courses, modules, activities), Didactic
media or Production tools used or produced within these activities. Each user follows (or supports, supervises,
manages, designs) a certain learning scenario. Each user has his/her own view of the learning scenario, media, and all other
resources he/she uses. This way, each document or tool can be parameterized differently by each user.
Conversely, each tool and document can accumulate data on its users.

Another important subcomponent of the VCE is the Communication-Collaboration Space. This component
includes both synchronous (real-time) tools such as screen and application sharing, whiteboards and groupwares,
desktop videoconferencing, and asynchronous (delayed-time) tools such as teleconferencing, textual and voice
mail or document and tool transfers. In this sub-environment, actors in the Virtual Campus can collaborate in
different ways, within teamworks, discussions groups or virtual classrooms.
The VCE gives the user access to the user to an Assistance System grouping a certain number of tools, on-line access to trainers and content experts, contextual help and intelligent advisor components. The advisors, whether on-line human and software components, use the knowledge model and the data on a user, accumulated by the scenario or other tools, to help this user in the accomplishment of its tasks.

The Knowledge model is a component, potentially accessible to every actor, that describes the designer’s view of the knowledge domain, that is the content, the scope and the purpose of the learning activities. It provides the essential links between the learning scenario and its activities, media and tools. It also provides a basis for the diagnosis of progress and achievements within the learning system.

Development of the scenario editor

First, the specification of the editor has been defined. Then, the implementation strategy was to build a basic foundation that can be reused for all the editors of the VCE. The scenario editor is the first implementation over the basic foundation. The development is done with Microsoft C++ reusing what it is possible from MFC.

Specification of scenario editor

The Learning Scenario of a Learning Event is a graph composed of all possible learning paths between the sub-Learning Events which constitute it. Adding to the paths are the Didactic Media and Production Tools necessary to execute a Learning Event. A special interest has been made on the possibility to integrate any kind of document or application inside the Learning Scenario through the concept of reference.

Learning Events are structured hierarchically. The high level is the curriculum and the last unit or leaf are the Learning activities which cannot be decomposed. The nodes of the Learning Scenario of a curriculum are the courses. The nodes of a Learning Scenario of a course are modules, and so on.

The Learning Scenario define the default learning path proposed to a learner for a Learning Event. This is the learning scenario established by the designer. A learning scenario may be adapted by the learner (or the team) to
become a personalized learning scenario. An adaptation can be for example adding a book to read on a missing knowledge or change the description of a paper to be produced, etc…

The objectives of the editor are to permit a designer to define these Learning Scenarios with a graphical user interface and to stimulate reuse of predefined Learning Events in facilitating the assembling. A viewer version is necessary for the learner. The main difference with the designer version lies in the limitation of the editing features. However a student can adapt the scenario by adding and removing objects. Another particularity of the viewer version is possible control over the navigation; in the learner viewer version, navigation through some part of a scenario is controlled according to the student progression.

Basic Foundation
In order to build as many compatible editors according to an infinite number of modeling formalism that can be needed to the VCE, a generic underneath foundation, called the Generic Graph, has been implemented. The Generic Graph acts as the underlying structural component. Not directly accessible to the actors, it constitute the basis of all the basic knowledge, scenario, media, tools, collaboration or assistance data, together with their interrelations. In the form of a structured graph on which the specification necessary to an editor of the Virtual Campus can be build over.

The Generic Graph is the fundamental structure from which every component of an editor is made of. It is the basic matter used to build the learning scenario model. All the basis mecanisms based on the Model - View - Controller architecture are implemented in generic classes to be inherited by all the constituant of a model. These basics mecanisms are classification, iteration, notification and serialization:

Classification: where type is determined by the position of the object in the structure of the semantic universe.

Iteration: standard ways to iterate inside the universe and node classification.

Notification: protocols for model dependencies.
Serialisation: standard support for saving node derived objects.

Learning Scenario Editor Implementation
Based on the Generic Graph, the Editor is composed of two main components; the model and the interface. The learning scenario model is modeling over the Generic Graph in an initial formalism and data structure. The interface allows to redefine the data values and networks.

Adding to edition capabilities to create and modify the Learning Scenario, are the possibilities to establish the project context where the Learning Events are used and to access to all existing Learning Events in the whole environment.

The viewer version permits to navigate through the Learning Scenario and consults what must be done to achieve a Learning Event or to realize the instructions of the Learning Activity.

For the learner, a telecommunication platform had to be selected for delivering scenarios and documents, and allow students to communicate and work together in an elegant manner. The Internet has been chosen opening accesses from home through basic ISDN links. Mixing the use of a specific OLE scenario viewer (which will be soon under development) with the Netscape WEB browser, and integrating communication features such as Mail, forums, synchronous cooperative work features (including videoconferencing) and others, will permit to deliver and test a living Virtual Campus.

Hereafter is an example of a make-up of the viewer designed for the Learner:

Conclusions and future work

The objectives of this work are to realize the navigational aspect required for the users of the VCE, specifically to give designer tools to create the navigational learning paths required for the learners of the VCE. The Learning Scenario Editor is one part of it. Other editors such as hypermedia editors will have to be or developed...
or integrated into the Environment to complete the functionalities necessary for all the roles of the five actor
categories.

The designer version is well advanced, the viewer version will be soon under development. Next to this
Learning Scenario Editor implementation, are the consideration of the impacts of collaborative works on
Learning Scenario. It is not only the possibility to produce collaboratively Learning Scenarios, i.e.: many
designers at a time, but to specify what is the impact of having a Learning Scenario including tasks such as
collaborative works. It involves integration of synchronous and asynchronous communication functions. Other
aspects that must be kept on mind are the dynamic links to establish between the Learning Scenario and other
editors. For example, a modification in the Learning Scenario may have an impact on the work plan of an
individual (or of a team) and vice et versa.

VCE management tools are planned to be developed for VCE manager to manage subscriptions and access rights.
Other functions such as private database to enable document exchange and collaborative production by a team
are also part of the development plan.

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Abstract: This interactive multimedia courseware program on French civilization incorporates seventy segments of documentary video entitled Un Mois en France that I wrote, directed, narrated and edited. The CD-ROM contains ten linked regional menus enabling the user to explore France geographically or by topic. Each segment presents a video and a scrolling window with the tapescript, containing green “hotwords” accessing additional information. Linked screens contain vocabulary and comprehension questions for each segment. All the 235 screens have fullscreen bitmap backgrounds of images from the project. The project is intended for intermediate speakers of French worldwide, and with the hard copy of the text files can be taught as a civilization course at the university level.
Telematics for Education: the Design of a Distributed Computer-Based Collaborative Learning System.

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Abstract: This paper describes a project for the creation of a distributed system integrating computer-based learning material, network services and communication facilities within an environment provided by W3 technology. The project represents on one hand the continuation of the activity of the Department of Biophysical and Electronic Engineering of the University of Genoa in development and testing of computer-based learning material for electronic engineering. On the other hand, it explores the pedagogical potential offered by the growing world of network communications.

The project aims to promote cooperative and distance learning in electronics for the students of the Diploma and Laurea degree in Electronic Engineering, using Internet to exchange information between tutors and learners.

1. Introduction: the Distance Learning Context

In the past few years, most universities and engineering schools have experienced a constant increase in the number of students. This poses serious problems to the institutes of higher education. Finding a good trade off between number of students and quality of the services offered to them and putting together two diverging realities, the increase in training requirements and the rarefaction of the resources which the community considers itself able to spend in this domain, is the task to face.

A solution to these problems may be sought in the use of new information technologies and in computerized distance learning [Smith 92]. These methodologies may play an important role in various systems of adult education, whether it be in university education, professional training, continuous training or industrial training [Reinhardt 95].

To our experience, putting at people's disposal good quality pedagogical materials is not sufficient in itself to guarantee an effective learning. In most cases, interactivity must be present to provide direct communication between the actors of the learning process. The learners need to have a communication with the teachers, to receive feed-back (encouragement, validations, assessment of their results) and also active intervention (obtaining answers to specific questions, providing criticism and suggestions). The teachers need a communication channel with the learners to obtain feedback on the effectiveness of the training process. However, it is also very important to establish a continuos communication between the learners themselves. This exchange of information, that is often overlooked in a superficial analysis of the learning process, plays a complementary role, being characterized by the absence of the psychological barriers that often exist between learners and tutors. A training system that relies on computerized distance learning must therefore seek to meet these needs.
2. Design of an Innovative Distance Learning System

2.1 The Learning Material

The design of a new and effective distance learning service starts from the analysis of already available and tested learning material [Ponta & Donzellini 94a]. The courseware developed so far by our institution within the framework of European cooperation, consists mainly of hypertexts, local simulations, exercises, animation and general purpose didactical simulators, covering almost every aspect of digital and analog electronics. With the exception of a few complex general-purpose simulation and design tools, the courseware has been developed using Asymetrix ToolBook. During the past year the courseware has been distributed to students by floppy disks and attended by students at home or in university labs equipped with stand-alone PCs, each with its own copy of the software installed.

Concepts and techniques used in the production of this material are typical of Computer-Based Learning (CBL) pedagogical applications. The use of computers is emphasized for the initiation and promotion of the learning process and provide environments that facilitate skill development and enhancement within particular task domains. Taking advantage of hypertext and multimedia structures, a fixed content, provided by the developer, plays the role of instructor in the delivery of the learning material. In our case, the CBL approach is enriched with simulation tools, i.e. software applications able to process a specific problem that is provided by the user [Ponta & Donzellini 94b]. A circuit simulator, for instance, analyses a network of electronic components that the operator provides as input and introduces the problems of real circuit design.

In the traditional course, the learner was a quasi-passive observer and listener of knowledge transmitted by an external center (the teacher). CBL aims to place at the center of the learning process the student that, therefore builds his own knowledge exploiting his own active experiences. The use of CBL allows the introduction of more material than by conventional means, and helps in the difficult problem of teaching students with a broad range of backgrounds. Taking advantage of multimedia technology, concepts are introduced with more than one approach, that is, using text, images, animation, sounds. Such variety of communication media make learning more attractive.

From studies regarding self-motivation and computers it can be concluded that the use of computers increases, at least at the start, the motivation of the students that have a better perception of learning compared with the traditional way [Schank 94].

Comparing CBL to traditional classroom learning it is immediate to realize that, if CBL brings about some advantages [Baker and Manji 92], classroom education has its strength in the possibility of interaction between the actors, namely teacher and learners, and in a continuous and natural upgrade of the contents. In our opinion the real potentiality and the innovative features of our proposal are to be found in the integration of the advantages of both.

2.2 A Distributed System for CBL Material

In a CBL environment, in order to guarantee the quality and the pedagogical effectiveness of the learning material, frequent maintenance is required. This implies the release of revised versions of courseware in order to add modules on new subjects and to incorporate up-to-date items like sample solutions of examination tests.

The rapid obsolescence of the material distributed with traditional channels, like floppy disks and CD-ROMs may be overcome by the use of network facilities. We propose to consider the global amount of learning material, that we subsequently call “knowledge pool”, as a distributed entity. This means that the courseware modules reside within their authoring institution and the users can access them from their own workplaces without necessarily having a local copy. Initially the knowledge pool is composed of the courseware in electronics produced by our institution, but the structure of our Distance Learning system is open to receive or to allow access to other material.

A distributed knowledge pool presents at least three advantages: there is no need of large storage spaces at the user’s side, all the students can use the current release of the courseware as soon as it is available and, last but not least, all students use exactly the same material.

2.3 Integration of CBL Material with Network Services
The greatest advantage of the solution that we propose with respect to any CBL system, comes from the communication facilities offered by the system. The exchange of multimedia information, cooperative learning and an effective teacher supervision of the learning process become possible, filling the gap between classroom and computer-based learning.

Our approach is to build a set of bulletin boards, dedicated to several subjects, where students and teachers can raise specific problems or exchange general information. Each course has its own bulletin board for information and discussion on the specific course issues. This allows the students to collaborate in solving problems, understand theoretical issues, exchange exercises and/or solutions etc. Another set of bulletin boards is dedicated to general communications and notices. Furthermore, the environment provides for personal communications, that are very useful to ask direct questions to the teacher. From the questions he/she is asked, and from the subjects discussed in the bulletin boards, teachers can compile a sort of Frequently Asked Questions (FAQ) list, relative to each course. The lists eliminate repetitive questions, by making answers available in advance, and helps the courseware authors to find out the topics that may need a better explanation. Teachers can also periodically propose exercises and receive the students’ solutions to evaluate the effectiveness of the classroom lessons and to encourage the students to work toward collaborative solutions by exchanging opinions and hints on the bulletin board.

The new environment will allow students to access asynchronously the services, either by the university network, in any department laboratory or computer classroom, or by phone. The growing diffusion of Internet opens our system to homes, university and, potentially, the world.

3. System Architecture

To actually build such environment, one possible solution would have been the custom development of dedicated graphical interfaces and functional modules implementing the required specifications, with the result of producing a stand-alone, closed system. Such system would have required a specific configuration for the user station and its expandability would have been limited, because of the need to design new software tools both on server and client sides in order to add new services. Portability to different platforms and sites would have been time-consuming and expensive. In our opinion, working in Internet, Word Wide Web (WWW) is the natural solution for remote access to the distance-learning service. WWW, indeed, is an efficient way for distributing up-to-date information; it’s a native open hypermedia platform which can well integrate many existing protocols for basic network services [Ibrahim 94] and for the specific ones that are offered by our environment. The choice of WWW as the common user interface, guarantees the users, especially the remotely connected ones, a great simplicity of system configuration and operation. Among the Web browsers available we’ve chosen Netscape Navigator, because it is free for non-profit organizations, such as universities, and it’s becoming a de facto standard. A scheme of the system architecture is reported [Fig. 1].
In the following, every part of the system is explained and details about the software solutions adopted for implementation are given.

3.1 Knowledge Pool

The knowledge pool is the collection of the learning material. Each module, developed using Asymetrix ToolBook, is composed by ToolBook files. Web browsers offer the possibility, by configuring the viewer, of exploiting external applications to handle any file format: this allows on-line usage of the courseware. File Transport Protocol, supported by the Web, allows the downloading of educational material for off-line use. Stand alone use of the learning material is one of the modes of operation of our system, to reduce connection costs and to further increase the availability of the courseware.

However, distributing ToolBook documents composed of multiple cross referenced files on the Web is not automatic, because the current version of ToolBook assumes having all the files available on the local machine. For this reason we have written a Dynamic Link Library (DLL) to interface ToolBook and Netscape Navigator, exploiting the Dynamic Data Exchange (DDE) support features of both. NeTbk.dll, this is its name, implements both a DDE server and client in order to allow ToolBook and Netscape to fully control each other, and in particular to transparently download ToolBook files when needed.

3.2 Communication and Cooperation

The collaborative learning subsystem, including bulletin boards, is developed by taking advantage, of the standard UNIX e-mail system and of a form-based interface to direct e-mail queries to the appropriate destination. A utility, MHonArc [Hood], translates files with the format of standard mailboxes into HyperText Markup Language
(HTML) linked files. Each bulletin board actually consists of an e-mail address. Appending a message is obtained by writing to the appropriate address. MHonArc automatically recognizes and decodes MIME (Multimedia Internet Mail Exchange) multipart messages as defined in RFC 1521 [Borenstein & Freed 93], including hot links to the non textual parts of the document in the HTML output. This allows the exchange and publishing of multimedia messages, and in particular of mixed text and graphics that is very useful, not to say necessary, for our specific field of instruction, where schematics, time diagrams and symbols are always part of exercises and must therefore be exchanged. Private messages can be sent and received with canonical e-mail.

3.3 Administrative Tasks

More traditional features of our system, such as teacher information, lessons schedules and exams booking, are implemented through a multi-user database engine. In this phase of the project we have chosen MiniSQL [Hughes 95], by Minerva Network Management Environment, because it is freely available and supports a subset of standard SQL, a language used by more powerful commercial databases. The interface layer between the database itself and the Web server, consisting of several Common Gateway Interface programs written in standard C, allows remote users to access the database and obtain its output as HTML formatted pages.

3.4 Registration to the System

In order to provide the system with a sufficient level of security, students are requested to register using an appropriate procedure. The students’ registration data, submitted to the system through a HTML form, are checked against a table of the database derived from the archive of the university students, to verify the identity of the potential user. Once the student is identified he/she is assigned an e-mail address and is given the possibility to fully access the system.

3.5 Client Setup

To use the learning material offered by the Web server, students need to configure their client machines. The system provides a tutorial about these setup operations. It is necessary to download the run-time version of ToolBook and the library Netbk, to install the software on the local machine and to configure the viewer associated to files with extension .tbk.

4. Conclusions

As already stated, the techniques to develop multimedia/hypermedia courseware are well consolidated and the feedback from the users, the students, while pointing out aspects that must be improved, nevertheless strongly encourages further research and development. On these bases, an effort has been made to integrate true interactivity into already existing pedagogical modules and into the design of future teaching material.

Distance Learning, from this point of view, can be seen as an extension of CBL, enhanced by the concept of collaborative learning within a distributed environment.

In order to test the real effectiveness of the presented Distance Learning environment, a course in digital and analog electronics, based on the new system, will be activated during the next academic year (96-97) for the students of “Diploma Universitario”, a short engineering curriculum (3 years).

A future extension of our system is the integration of video sequences from real classroom lessons into the hypermedia courseware. Another one could be to extrapolate a student model from the activity done on the system. Such a model could help the learner make better use of the very large amount of available material, by building a customized learning path.

We believe that the application of Distance Learning technology, as proposed in this paper, may also apply to the industrial situation. The impact may be not only on training practices, but also in remote process controls and real time diagnostics. The current state of the art in this field is based on extremely expensive proprietary technologies,
while a more open and standard approach may result in enormous advantages especially for small and medium enterprises.

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Abstract: The telelearning project of the University of Twente, the Netherlands, will enable all sorts of new tele-educational options for large groups of students. Teachers, students and learning materials can be at different places in telelearning settings. The university is implementing a fast connection to its network facilities for all students and staff members from their home sites. The telelearning project is meant to stimulate and coordinate the development and use of these new technologies in education. In this project the University of Twente cooperates with the national Dutch telephone company and the regional television cable networks company. We expect in this project to enhance the educational use by teachers and students of the technical infrastructure. The goal of this project is to achieve a shift in the teachers focus with respect to the opportunities of telelearning using a step by step implementation strategy.

Introduction

The University of Twente is a university for technical and social sciences. It employs 3000 staff members and the number of students is 7000. On the campus live about 2000 students, whereas the rest is living in the region of Twente. At the moment computer and network facilities are available for students in the university buildings. Some of these facilities are open in evening hours. All students have E-mail boxes. The 2000 student residencies on the campus have Internet connections through the campus network. Outside the campus some 1000 students have dialback facilities connecting their home pc to the university network.

Most of our students have a computer at their working place at home. In most curricula students use the computer for word processing, spreadsheets, databases, simulation packages, CAD/CAM, computer aided learning, mathematical packages like MAPLE and DERIVE etcetera. In some departments access to a private computer is obligatory as the computer is used very often in the curriculum. In order to facilitate the use of computers in the curriculum students are offered university loans to buy a private personal computer and there are fundings for campus licenses for software.

The use of electronic mail facilities and access to World Wide Web is still not as normal as the use of the pc is. There are some initiatives for educational use of World Wide Web and electronic mail facilities in the departments of Educational Technology, Applied Communications and Business Information Technology. In all other departments this sort of use of information technology is only occasionally.
Staff members use network facilities widely for research and administrative purposes as well as for communication. Nevertheless, only a few staff members apply telelearning methods in their courses.

Goals of the project

In order to stimulate and coordinate the development and use of new technologies in education the Educational Centre and the Computer Centre initiated the so-called ‘University of Twente Tele-learning Project’. A comprehensive description of this project is given in [Veen and Koppen 1995]. The general goal of the project is to achieve a shift in the teachers focus with respect to the opportunities of telelearning using a step by step implementation strategy.

More specific the project has the following goals:
1. To stimulate telelearning at the University of Twente in an integrated approach.
2. To design, test and implement new educational methods and technologies using information and communication technology.
3. To implement a technical and organizational infrastructure, so that all students and staff members can have a fast connection from their computer at home to the campus network and Internet.
4. To bring together people within the university having experiences with telelearning. We hope that in an informal way these people can stimulate each other as well as novices in this field.
5. To make an inventory of projects in order to coordinate activities with similar goals and to enhance cooperation.
6. To disseminate the knowledge on telelearning within the university as well as outside.
7. To find financial resources for pilot projects.
8. To enhance our teleteaching profile for the outside world and to make clear where to address the university for educational teleteaching projects.

In order to reach these goals the project as a whole is split into two main streams: a technical, infrastructural part and an educational part. But both parts are strongly interrelated. During the last years we encountered the problem that infrastructural facilities have been realized without direct application in education. Large investments in technical supplies did not lead automatically to useful applications of new technologies in university education, but rather raised a lot of criticism about ‘waste of money’ from the teachers side. Therefore now an integrated approach has been chosen, in which the extension of the technical facilities is coupled to educational applications and pilot projects at the same time.

Organization

A step by step implementation strategy will be applied in order to reach the above mentioned goals of the project. This strategy implies research and activities on three levels:
− the level of an actual problem in the educational practice of a course in a curriculum,
− the level of a common problem in the educational practice of a curriculum or of more or less identical courses in different curricula,
− the level of generalized educational theories in the field of scientific educational research.

Most of the actual telelearning activities are on the lowest level, the level of a specific course in a specific curriculum. We observe a lot of initiatives on this level with identical objectives, identical problems and mostly also identical solutions for these problems. But unfortunately, people are operating independent from each other without knowing the efforts of their colleagues within the same university in solving the same problems. Pilot projects in the field of application of information and communication technology in education have been started originally as independent projects. The ‘Tele-learning Project’ aims to coordinate these projects, to relate them to each other and to raise the individual projects from a lower level towards a higher one.

To overcome the situation of more or less isolated pioneers and to raise their activities to a higher level we organized the ‘Tele-learning Project’ in the following way.
1. A supervisory board with experts from the university as well as from the Dutch telephone company and the cable network company has the function of the master-organization. This board masters both the technical and the educational part of the project.
2. A small project office with a manager is responsible for the daily coordination and execution of the educational part of the project. The manager is the secretary of the supervisory board. The educational input is provided by a four member committee. These four members are the deans of the faculties of Educational Technology, Computer Science, Chemical Technology and Applied Communications.

3. A small project group with technicians from the Computer Centre and the Telecom company is responsible for the technical part of the project.

4. Computer experts and educational specialists as representatives from all faculties of the university form together an advisory council for the management board of the university. The manager of the project office is the chairman of this council. Via this council communication is guaranteed with all departments of the university and also with the university board.

5. In order to enhance student involvement in the use of information technology in education technical assistance and support, e.g. a help desk for the technical infrastructure, is given by students.

The organizational structure has been set up recently. Within the university community there is a great support for the initiative of such a more structured approach to the implementation of these new technologies in education. There is a formal approval from the faculties and from the university board for this organization.

**Technical Infrastructure**

The goal of the infrastructural subproject is to offer at the end of 1997 each student and staff member an ISDN connection between the home place and the university network UTnet for a reasonable price. This subproject about the technical infrastructure has reached the phase that outside the university campus about fifty to one hundred students and/or staff members in the region of Twente will have a direct connection to the campus network via ISDN.

The technical infrastructural experiments will concentrate on the geographical and practical limitations of the connections. Also the setting up of the administrative organization, the help desk function and the technical support are relevant in this phase. With respect to the help desk function there are good experiences with setting up a student association that is responsible for primary support e.g. installation of communication software, connection of modem, etc.

The selection of students and staff members for this phase will be based primarily on the participation in relevant educational projects. In this way the setting up of the technical infrastructure is directly coupled to educational experiments. This phase is planned from March to August 1996.

From the start of the new academic year in September 1996 the number of connections will be extended by two or threehundred a month. Priorities depend on the participation in further educational projects or on the needs in regular courses using these facilities. At the end of 1997 each student and staff member can have a ISDN connection from home to the campus network and Internet.

**Educational Projects**

Most of the educational pilot projects in relation to the use of information and communication technology are on this moment limited to students working at their home places at the campus or working in the university buildings at the campus. A consequence of this situation is that students and computer rooms at the university have to be scheduled in a rather strict way. The advantage of flexibility is missing. Most of the students living outside the campus have pc facilities at their home place, but not a connection to the campus network. They can have a dial back connection, but because of the increasing application of multimedia in communication and also in the course contents this connection is too slow.

Many of the educational projects have to do in some way or another with collaborative distance working. An example of such a project is described in [Pouw 1995]. These projects are generally in the first execution not as successful as the teachers expect they will be. People are therefore reluctant and hesitating to share their experiences with colleagues. This leads to the situation of different people trying to solve identical problems independent from each other. In this there is a clear task for the project office.
The project office has started now in the faculties an inventory of educational activities related to the use of information and communication technology in education. The approach is very direct by using the personal networks of the project manager, the advisory committee and the supervisory board. The result is not only a list of educational experiments, but also research projects in the faculties of Educational Technology and Computer Science. These projects are mainly on the highest level of generalized educational theories, but they can be applied in the daily practice of university education.

The next step is to bring people together. Informal meetings have been arranged with personal invitations to people involved. Round table discussions give people a mutual insight in the disappointments, the problems and the difficulties, which are sometimes on the most basic level of e.g. e-mail failures. But fortunately there are also success stories and inventive solutions for unexpected problems. The approach of informal meetings is essential. People can communicate in a rather easy way on a very practical level. We observe that important objectives of the project as a whole are going to be reached. We bring people from the university having experiences with telelearning together. We see that in an informal way these people stimulate each other and look for cooperation and that also the knowledge on and the experience with telelearning within the university is disseminated. The three levels as mentioned in the beginning of paragraph 3 are going to be intermixed.

We are still in the beginning phase of implementing the use of information and communication technology in university education. But the experiments are rather promising. A lot of difficulties have to be overcome. But the more structured exchange of experiences between teachers and researchers by small scale, informal meetings accelerates the process towards successful projects.

How to go on?

Only a campus network has to much limitations for a successful implementation of information technology in education, as to much students live outside the campus. A direct connection from the home sites of the students to the campus network is a necessary condition. We expect the quality of connections to the campusnet to enhance greatly for students and staff outside the university.

With the help of students technical problems, that otherwise should have frustrated the use of home connections [Collis 1992] have been minimized.

A lot of pilot projects on the course level demonstrated a need for a more systematic approach of applying information technology in the curricula. Most use of these projects concerned communication and Internet use. Other educational use of these facilities by teachers have been started only on a small scale. A lot of teachers need more experience with these facilities for professional purposes first. In combination with examples of successful telelearning pilot projects, an exchange of experiences and coordination of diffuse activities we expect more teachers will start using the teleteaching facilities. The project office is going to be the ‘ticket window’ from which teachers can be led the way to colleagues who preceded them in a comparable situation.

References


Abstract: This paper introduces the experience of a multicampus university, (the University of Ulster), in the delivery of distance education over a period of six years. The University's digital educational videoconferencing system was one of the earliest to be installed in the UK. The core of the paper concerns an experiment to link the University of Ulster videoconferencing system with that of the University of London LIVENET system via a low bit rate connection namely, ISDN2. The technology of ISDN (Integrated Services Digital Network) is described, as is the technology of the audio/visual display used in the exercise. The experience in using this Ulster/London link over several years is reported as are insights gained from a more recent BT project (ACTOR: Application of advanced Communications Technologies to extend OutReach). Some projections for future development are then discussed. Current advances in the technology of educational videoconferencing abound, particularly in the areas of image compression, information processing, digital storage, available bandwidth. However, the most important pointers to success will be determined by the future levels of usability and user acceptance.

Recognition of this factor underlies much of the rationale of the University's ongoing user appraisal studies, in which the future of educational videoconferencing is predicated on the educator being in the driving seat, rather than the technologist and further predicated on the interests of the learner being uppermost in the evaluation process. The feedback on this experience is substantial and is discussed in the paper. These projections herald a future of high promise for digital videoconferencing, which will be both radically distinct from its predecessor technology, namely analogue videoconferencing and far richer in the number of new applications in distance education delivery, to be realised. The paper will conclude with an account of current and proposed developments in educational conferencing (in all its guises) between collaborating universities in Europe. These collaborating institutions of higher learning have grouped themselves into consortia for the purposes of sharing academic expertise and research specialist knowledge, as well as achieving economic benefits.

Introduction

The University of Ulster in Northern Ireland, because of its layout, (four dispersed campuses across the province) and its special mission (educational outreach to the community) has had a long standing and serious interest in the benefits to be derived from the employment of technology supporting distance education between campuses and specialist training in local industry. In 1990 the University commissioned one of the earliest digital videoconferencing systems in a distributed university environment, joining three of its four campuses, namely Jordanstown, Coleraine and Londonderry. The Londonderry campus is 32 miles from Coleraine and 72 miles from Jordanstown. The system is intensively used for the academic programme of lectures and seminars [1]. The system is also used by academic and administrative staff for meetings and other university business. In the context of videoconferencing usage, the University has carried out a sustained user oriented programme of monitoring the impact of the system on its academic programme both from the tutor and the learner perspectives, manifested in two reports carried out previously [2].
The Ulster videoconferencing system is deployed with a H.261 codec located in each of the three campus sites, joined by a 2Mbit/s line over SMDS (Switched Multimegabit Data Service). An MCU (Multipoint Control Unit) links the sites in any desired pattern. By virtue of additional interfaces to ISDN, the MCU can link to external sites and effectively extend the 'footprint' of the University's internal inter-campus system. The lecturer sits at a desk facing the class at the local site and can see the distant site on a small monitor on his/her desk. The lecturer can also communicate with the distant site via a camera at the back of the distant class room, which the tutor can control remotely for zoom or focus by using a touch sensitive tablet and stylus at the console. This sends a signal to a Tandon-386 cue computer at the master site. Each tablet has a seating plan of the videoconferencing suites. The lecturer's graphical support (in the shape of diagrams, pictures, headings et al.) appears as still images on a second monitor in each suite [3]. A prime rationale for installing this system was to ensure the availability of important courses to a dispersed student population with a thinly distributed demand. The appraisals referred to here, relate to the delivery of courses, which, in the main had been developed for traditional media and delivery.

The appraisal of the videoconferencing system was a formal exercise. It included both internal evaluation by the course tutors and external evaluation by appointed research staff. The methods adopted, included interviews with lecturers and students, attendance by evaluators at course sessions, and the completion of questionnaires. It also included access to and analysis of tutors' videoconferencing files, notes and diaries throughout the course of the academic year. The programme of successive appraisal provides feedback to successive semesters and to planned future extensions and upgrades of the technology. The studies looked at issues such as 'techno-stress' in the tutor population, the nature of the impact on the tutors' pedagogic styles. They also considered specific concrete issues such as legibility of the video monitor, the alignment of cameras with monitors to enhance tutor/student communication and the contribution that in-session hardcopy facilities (such as a fax machine) would have on education delivery. This was before the availability of desktop fax over ISDN2. The studies suggest that the use of videoconferencing techniques challenges the teacher more than the learner, also that each course delivered by videoconferencing methods should include some measure of face-to-face contact. In general, it was thought that videoconferencing had a positive role to play in the delivery of educational courses, confirmation of which lies in the recent decision for proposed extensions in the use of videoconferencing in the University. It was also found that the employment of videoconferencing techniques encouraged students to become more responsible for their own learning patterns, also promoted group cohesiveness, group independence of the tutors and flexible patterns of learning.

The University's programme of appraisal and evaluation continues and during the course of the next year will evaluate the effectiveness of the use of videoconferencing as a vehicle for the delivery of a postgraduate course of study. In 1993, the University of Ulster connected its three campus videoconferencing system to an educational videoconferencing network at London University, using a narrow-band transmission link in ISDN (Integrated Services Digital Network). The occasion was a new course offering Human Computer Interaction (HCI) transmitted by LIVENET, (the London Interactive Video Educational Network). The videoconferencing vehicle was a 128 Kbit/s communication product from British Telecom - the VC7000, which is essentially a desktop unit which complies with H.261/H.320 over ISDN2.

The Human Computer Interaction Module

The new course referred to above was a module in human computer interaction, specially developed jointly by University College London and Imperial College of Science & Technology for videoconference delivery [4]. This course aimed to equip students with the necessary skills and experience to design, implement and evaluate human interfaces to interactive computer systems. The rationale for including such HCI modules in the Computer Science syllabus, recognises the paramount importance of the user and the user's needs in the development of today's computer applications. Human Computer Interaction, as a academic topic of study and research, is a relative newcomer to the academic scene, having its origins in the nineteen sixties, when initial efforts were made to improve the usability of computers. The progress of HCI as a subject was accelerated with the advent of the personal computer and the concomitant rapid growth of a non-professional user population. The subject matter of HCI is inherently interdisciplinary, drawing on psychology, ergonomics (human factors) and computer science. More recently, disciplines such as sociology, linguistics and anthropology have contributed to the syllabus of HCI. The course, was assembled as a series of nineteen lectures starting in January '93 and extending over the following ten weeks of the Spring Semester. The lectures were given alternately by UCL and Imperial College with some input from the University of Ulster. Each of the three participating institutions organised their own follow up tutorials, seminars and revision sessions. They also organised their own assignments, tests and end-of-term examinations.
The Enabling Technology: Telecommunication Infrastructure

The British Government, in conjunction with the European Commission and BT, invested heavily in the telecommunications infrastructure of Northern Ireland. The following section report on the background and implications of these developments for the multimedia industry.

The Special Telecommunications Action for Regional Development Programme (STAR)

The need for an adequate telecommunications infrastructure has been an issue of very great importance for Northern Ireland, a region with uneven distribution of economic activity, and corresponding variations in population density and industrial activity profile. The need for improved infrastructure was further reinforced by the fact of being located on the periphery of the European Community. The result was the STAR programme. This programme was unique in that the level of telecommunications provision deployed by BT, was substantially in advance of the actual current business requirements in the greater part of Northern Ireland. Indeed, during the early nineties, Europe's first SDH (Synchronous Digital Hierarchy) 3-Ring system was commissioned in Northern Ireland by BT, with capacity to support between 155-622 Mbits/s [7]. The STAR rationale was based on the conviction that peripheral regions, and rural locations within these regions, must have adequate state-of-the-art digital communications services to compete successfully across Europe and beyond. Having upgraded the underlying infrastructure and exchanges within Northern Ireland to provide an essentially world-class system, BT then made available a range of digital services in the public domain, namely Basic-Rate ISDN, Primary-Rate ISDN, SMDS and ATM as new methods of transport. Each transport level provided different bandwidth at differing tariffs. The experiments discussed herein concentrate on the entry-level transport service, ISDN.

ISDN: Defining the Concept & the Terms

The conversion of telecommunications networks to digital transmission and digital switching is well under way. Economic pressures and advances in semiconductor technology have led to the increasing use of digital technology in Public Telephone Networks. Today, digital techniques are being used not only in inter-exchange transmission but also in subscriber loops to the user's location by incorporating analogue to digital converters into telephone handsets (hence higher quality and faster connections), and transmitting the data over 64 Kbit/s digital channels. However, end-to-end digitization allows the standard 64Kbit/s channels employed throughout digital telephone networks to be used, not only for encoded speech but also for a wide range of new and existing non-voice services. The further evolution of the IDN (Integrated Digital Network) is combining the coverage supplied by the geographically extensive telephone network with the data carrying capacity of digital data networks. This leads to the concept of ISDN (Integrated Services Digital Network) . Integration occurs in the simultaneous handling of digitized voice and a variety of data traffic on the same digital links and by the same digital exchanges. The key to ISDN is the small additional cost for offering data services on the digital telephone network, whilst incurring no cost or performance penalty for the voice services already carried on the IDN.

Interface Structure: The interface structure defines the maximum digital information-carrying capacity across a physical interface. The allocation of this capacity is accomplished using channels. Channels are classified by channel types (e.g. bearer andsignalling channels).

Bearer Channel: Commonly called a 'B' channel, the bearer channel is a 64Kbit/s channel which conveys customer information streams from one end point to another. The distinguishing feature is that it does not carry signalling information for circuit switching by the ISDN. Examples of user information streams include digital voice, data, text, video and facsimile.

Signalling Channel: Commonly called 'D' (for Delta), the signalling channel conveys control information for circuit switching by the ISDN. Enhanced signalling capabilities are offered to the ISDN services because the transfer of user and network signalling information does not interfere with the transport of user data on the B-channel. In addition to carrying signalling information the D-channel might optionally be used for transport of slow-speed data and for telemetry information. Due to the larger data rates which result from the use of digital technology, a channel structure of two B-channels and one D-channel is made available at the ISDN user network interface by existing two-wire subscriber links. These can be bundled to provide Basic or Primary Rate services.

Basic Rate & Primary Rate Services: ISDN services are divided into Basic rate and Primary Rate, each having a different combination of B-channels and D-channels.
Basic Rate (2B + D): Basic Rate access is over two 64Kbit/s B-channels and one 16Kbit/s D-channel plus 48Kbit/s for framing and control. It is presented to the customer at a standard interface known as I.420. Basic Rate (BR) was designed to be carried over the conventional copper pair normally used for a single analogue telephone line, but it can of course be transported via other media such as optical fibres or radio. The Basic Rate launched by BT on System-X is called ISDN 2 and is conformant to the international customer interface standard (2B+D I.420).

Primary Rate (30B+D): Primary Rate (PR) service offers 30 x 64Kbit/s B-channels and one 64Kbit/s D-channel (except in North America where the digital system hierarchy offers 23B+D). It is principally used to interconnect digital ISPBXs (Integrated Services Private Branch eXchanges) over 2Mbit/s links to digital local exchanges. The internationally conformant signalling presentation for PR is I.421, and currently the BT service called ISDN30 is adopting this standard. The previous proprietary signalling system called DASS2 (Digital Access Signalling System No. 2) was adopted by ISPBX suppliers some time ago and accounted for BT's ability to claim a world first for the launch of a commercial PR service. BT will provide a full I.421 presentation in due course.

CPE (Customer Premises Equipment): ISDN relies not just on a network functionality but also on the availability of CPE and applications. This is an area which is still in its infancy, but numerous developments have already emerged:- Terminal Adaptors (TAs) and Digital telephone sets. TAs will be widespread in the early days of BR-ISDN as they allow existing terminal equipment to use the I.420 interface. As many TAs have a handset for voice capability, it can become a matter of choice whether a unit is called a TA with a handset or a digital telephone with a TA.

Videotelephony & Videoconferencing: Terminals are already available which provide good quality vision for conferencing purposes. As costs of the terminal equipment reduce with volume this should be a major growth area. A typical application would require the two BR-B-channels (equivalent to 128Kbit/s from which 16Kbit/s is allocated for speech with the remainder used for video information). The example terminal equipment, adopted as part of the pilot exercise being reported here, was the VC7000 videophone.

The Desktop Technology: VC7000 VideoPhone

In the early nineties, several European telecommunications companies accepted an invitation to participate in a collaborative programme on the development of products and services for the videophone market. Six of the telcos, namely BT plc, Deutsche Bundespost Telekom, France Telecom, Norwegian Telecom, PPT Telecom Netherlands, SIP Italy - took up the invitation, becoming signatories to a five year memorandum of understanding on the European Videotelephone (EV) programme. The main aim of the EV programme is the introduction of a pan-European videotelephone service. The technology is relatively new and even though there are international CCITT standards, in the guise of Recommendation H.320 relating to narrow-band visual telephone systems and Customer Premises Equipment, there has been limited widespread experience with the available technology. Co-ordinated by British Telecom laboratories, the project was progressed by the European telecom consortium to develop a series of videophones that would be in conformance with the CCITT standards. Several videophones were designed and interworking tests between them were conducted successfully. One such unit is that developed by the Norwegian company Tandberg Telecom, which has been adopted for use in the UK by BT [8]. As a result of further recommendations by the BT/EV team, the Tandberg kit has now been enhanced & launched as a BT portfolio product, namely the VC7000 compact videoconferencing system. The VC7000 unit conforms to Recommendation H.320 which embraced the better known recommendation H.261 relating to video encoding algorithms. The videophone is digital and designed to operate across ISDN2, which is being deployed as a service throughout the European member states. As stated in the previous section, an ISDN2 line provides two B-channels which may be used together or separately. Whilst the VC7000 will operate at 1B or 2B default, selection was made to have all units work to the latter rate. Other restrictions relating to picture resolution and audio coding were adopted.

Picture Resolution: A video picture's spatial resolution consists of a number of pixels (picture elements). Common Intermediate Formal (CIF) is a resolution originally defined to allow the transfer of video between NTSC, the technique used in the USA, and PAL, the format used in the UK. CIF pictures employs 376 pixels per line with 288 lines per picture. A reduced resolution termed Quarter-CIF (QCIF) has found much application in low bit rate video coding. The trade-off is between spatial resolution (i.e. sharpness of detail in a picture) and the temporal resolution (i.e. the number of frames per second, thus the tracking of the motion). In situations with low motion content (such as typical videophone scenarios) CIF resolution is often found to be superior, although many manufacturers have developed QCIF as the default to give better rendition of motion.
Audio Coding: As indicated above, a transmission rate of 2B was adopted by the VC7000. On initiating a call, the videophone units exchange capabilities - this is more or less a handshaking process whereby the units inform each other of their functionality and defaults settings. The units then switch to the highest mutually acceptable mode of operation (and hopefully performance). This is generally taken to be CIF video coding with high quality audio. In the case of two VC7000s calling each other, they will default 16Kbit/s for audio, leaving the rest for higher quality video. Additional features exist relating to hands-free audio, the ability to interface external and higher quality cameras and monitors (including rostrum cameras for graphics or documents), freeze picture facility, audio mute etc.

Experimental Phase and Considerations

The communication service adopted by the Ulster-LIVENET pilot exercise, was ISDN2 with VC7000 videoconferencing units at the Derry campus and the London end. At the LIVENET end, the audio and video input/outputs were interfaced to the external microphone and cameras of the Senate House videoconference studio. The resultant transmission quality considerably improved by these enhancements [6]. While the VC7000 is presented as "feature rich", there were a number of sought for features, which the Ulster-LIVENET collaboration brought out. Several issues addressed the performance of the on-board microphone in the VC7000 and the resolution of the VC7000 camera unit. It should be borne in mind that educational videoconferencing applications were not amongst the original VC7000 applications. Also the lecturers visual aids (overheads and the diagrammatic material) being recorded by the external rostrum camera had to be held rigidly as the transmission rate resulted in appreciable times being taken to handle overhead slide movements and such like by the lecturer. Nevertheless, the exercise between Ulster and the London colleges, to transmit the HCI module over a full academic term, was successfully concluded at the end of the Spring semester. For the purpose of the LIVENET exercise, Panasonic Camcorders (with both guided and free space connections) were connected to the VC7000, via a master control panel. In addition, for flexibility, and in particular for accepting questions from the floor of the lecture theatre, a radio microphone was used at the University of Ulster. It was also possible to expand the functionality of the basic VC7000 unit, by taking the audio output and feeding it into the public address system of the lecture theatre. In addition, the video was projected to a back-projector which in turn displayed it on a 10x6 ft screen at the front of the lecture theatre. This improved the functionality of the base unit in providing a more effective group-group conferencing environment, utilizing the existing lecture theatre facilities to emulate the lecture experience.

As may be gleaned from this paper, the investment by the University of Ulster in digital-conferencing networks as a delivery mechanism continues to be very significant. It may be said that the University has investigated the full spectrum of available bandwidth from 64Kbit/s to 2Mbit/s and beyond. The University is also exploiting its experience of educational videoconferencing in various ways. In the context of the DAVIDE (Digital Audio Video In Distance Education) proposal [9], it intends to explore the implications of extending its links with colleges in the London area. The University is also a partner in the TIRONET (Trans Ireland Optical NETwork) project. The TIRONET project is based on an advanced optical fibre network linking Belfast and Dublin and is funded by the EC RACE (R&D in Advanced Communications Technologies in Europe) programme. The University of Ulster is also in the unique position of having four distinct nodes on the UKs Superhighway, SuperJANET. This provides a high speed infrastructure linking all four campuses over SMDS to transport video, data and telephony traffic between the sites at bandwidths between 10-34Mbit/s. Plans are underway to increase the bandwidth in order to take advantage of ATM access in the future, which will enable the University to participate more fully in collaborative ventures with the other 50 or so institutions which are also part of SuperJANET.

More recently, BT has signed agreements with Olivetti, ICL and IBM to develop software around its new portfolio product, the VC8000. This is essentially the next generation of desktop technology to come to the marketplace and is based on a PC platform, providing connectivity to ISDN2 and a range of applications to permit such facilities as 'shared whiteboard', file transfer, fax, video/audio conferencing, and most powerful of all, MS-Windows applications sharing. It is the latter that is providing the new impetus and functionality into the desktop conferencing industry. Providing the ability to 'share' the content of any Windows application, whether it be educational software, a multimedia development tool, etc., is a very powerful attribute in a market sector which has a distributed presence. Such technology is providing the 'engine' for a new project between BT and the University of Ulster, namely the ACTOR initiative [11], which has been built on the success gained from the University of Ulster-LIVENET experience, and will provide the technology platform to take our user community to the next level in distributed course provision, planning and recruitment.
Hurdles Still to Overcome

Experiences with the Ulster-LIVENET and ACTOR projects has thrown considerable light on some of the more subtle issues which are inhibitors to widespread uptake of the technology, both within the education sector and industry. These can be summarised as follows:

- distrust of the technology (security and learning implications)
- perceived requirement for technical competence on behalf of the user (lecturer)
- lack of adequate protection on copyright and IPR (course materials)
- general apathy and employment implications
- overhead in material preparation for digital delivery
- ability to remotely assess students in real-time (and off-line)
- provision of simple ‘floor management protocols’ for on-line sessions

Several of these 'hurdles' are being addressed by basic human factor technology, but others will take more time to overcome, such as the 'distrust' and concern for employment contracts. The inference is that by being on the 'net' it is just as easy to receive as to transmit. Through the ACTOR project, the issues concerned with material preparation are being examined, adopting best practice techniques and multimedia authoring tools to 'ease' the transition from 'chalk & talk' to 'link or sink' methods of delivery in ever increasing competitive markets. Much work requires to be done before we have environments that overcome all the hurdles above in an inexpensive, desktop platform.

The future development of digital videoconferencing, is guided by a subtle mix of demand pull and technology push. Presently, the prevailing criterion for investment is to establish the economic justification. This criterion is succinctly articulated in the recent funding initiative of the UK Universities Funding Council "to make teaching and learning more productive and efficient by harnessing modern technology" [2]. The question of the day, is how to service the current demand to extend educational services to an ever increasing number of students against a background of progressive year-on-year cuts. This paper represents a group of statements each one reporting its own area of expertise, including costs and benefits, tariffs, service provision, telecommunications and network operations. In Ulster, the continuous investment by the University in the technology of videoconferencing represents a significant ongoing commitment, if the discharge of its mission to provide the maximum number of educational options across four dispersed campuses is to be fulfilled.

Conclusion

The pilot project with LIVENET (and more recently ACTOR) provided conclusive evidence of the role of ISDN as a facility to extend the reach of educational delivery, not only to other campuses and universities, but as a basis for outreach to the community. It also indicated the way in which specialist skills and experience may be shared on a flexible and cost effective basis with other universities. It can be said, in the main, educational videoconferencing largely employs traditional techniques of pedagogy "the chalk and talk" of the traditional paradigms of educational delivery. Refinements in the technology such as adaptive audio systems and robotic cameras are still largely in the development stage. Furthermore, the distinct advantages that digital videoconferencing has to offer over its analogue predecessor, are not either being fully understood or being effectively utilised. Digital videoconferencing is largely viewed by producers, programmers, and editors alike, as just a new form of analogue video, giving us a transitional "horseless carriage" period, rather than making a clean break to establish a new basis for the future of video design & development in a fully digital environment. The radically different and more powerful features that digital videoconferencing has to offer in the areas of production, storage, reception and transmission, are but slowly being acknowledged [10]. For example, in digital video productions, a much extended range of user interaction techniques are available. Digital video at the receiver end offers unprecedented flexibility, in the wide range of reception options, including frame rate independence, aspect ratio independence, format, resolution, bandwidth and screen size independence. Technical advances in digital storage have introduced the concept of "dial up" movies and video. Digital videoconferencing transmission is often discussed in terms of alternate delivery channels, either via computer networks, terrestrial broadcast, cable, satellite broadcast or telecommunication delivery. In fact, the future availability of digital video should result in a plurality of concurrent options, where the determinant for delivery of multimedia-conferencing will simply be the location of the user and the convenience of the user, irrespective of whether the user is in the home, classroom or office. In this scenario, educational multimedia-conferencing is proposed as one of a range of future value-added information services together with other tele-working and leisure options. Current advances in the technology of educational multimedia-conferencing abound,
particularly in the areas of image compression, information processing, digital storage, available bandwidth. However, the most important pointers to success will be determined by the future levels of usability and user acceptance. The future of educational multimedia-conferencing is predicated on the educator being in the driving seat, rather than the technologist and further predicated on the interests of the learner being uppermost in the evaluation process. These projections herald a future of high promise for digital multimedia-conferencing, which will be both radically distinct from its predecessor technology, namely analogue videoconferencing and far richer in the number of new applications in distance education delivery, to be realised.

References:


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Distance Learning System for Telekom Slovenije

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Abstract: Distance learning (DL) is very important for employee training, especially where spatial and temporal barriers are present. Telekom Slovenije, the major Slovenian telecommunication network operator and service provider, analysed the circumstances and possibilities for the implementation of a distance learning system as a means of training its employees, and the possibilities for using the same system as the basis of a new value added service. We analysed our current and future training needs and sought the areas in which DL could be implemented. Potential outside users of the system were identified, technical circumstances were scanned and strategic issues were discussed. Among various possible solutions for computer and telecommunication supported DL systems a proposal for the most appropriate pilot system was selected. Once the pilot system is implemented, we expect it to play an important role in internal training and to be a tool for analysing the further development of DL system in Telekom Slovenije.

Introduction

Knowledge is the basis of successful work. Though certain knowledge can be gathered from the work itself, it is mostly a result of a well-planned process. Within this process training activities and goals are planned and performed in accordance with the present and desired levels of knowledge. Given that enterprises in different areas of the economy have specific requirements, the knowledge acquired through formal education needs to be complemented. On the other hand, rapid progress and changes impose the need for continuous upgrading of knowledge. Training today is a continuing process.

Generally, a DL system is implemented in order to overcome some weaknesses of the classical educational and training systems:

- Education requires extensive use of human resources and DL may reduce the amount of human work and thus be more cost effective. DL can be profitable in comparison with the classical methods if the size of the target population of a certain training course is large enough. The costs of preparation of a DL training course are significant, but the number of participants is almost unlimited. In classical training the cost more or less correlates with the number of participants.
- Furthermore, when using classical methods trainees have to be gathered in the same place at the same time. This can be a big problem especially in employee training, because of their highly loaded schedules or time and money consuming travels.
- Lessons are normally held for a group and the pace and method are adapted to an average trainee. However, one trainee may need a more thorough explanation, while another, with a higher entry level of knowledge and understanding, would like to dedicate less time to certain topics. Smaller groups indeed solve this problem rather successfully, but they increase the costs of training.
Distance learning (DL) is suitable for overcoming spatial or time barriers, enables self-paced training and, if the number of participants is large enough, makes training more cost effective. It has been proven that computer and telecommunications supported DL can be faster than classical methods, provides a uniform level of knowledge and enables prompt delivery of training materials and thereby faster completion of a course. Better efficiency of DL is evident in the reduction of costs of employees' absence from work.

The development of communication technologies, the interconnecting of computers in computer networks and the popularisation of information services have created new opportunities in the computer-assisted training, learning and education. Services like e-mail, WWW, gopher or access to databases and the storing of courseware are widely available and make up the groundwork of different DL systems. They enable us to access and work with learning materials, manage our training activities, perform formative and summative assessments, communicate with tutors, experts and colleagues, or carry out administrative and other activities relevant to the training. Computerised systems offer the possibility for interactive work and feedback to trainees as well as to tutors or DL course designers.

Different ways of using computers and telecommunication systems for learning and training purposes can be illustrated by the following situations:

- **Stand alone computers**, which are not interconnected in any computer or communication networks, can serve as the basis of computer-based training (CBT), computer-based assessment or computer simulations. In this way we can follow tutorials and manage our training activities, keep records and logs and plan the learning process. The common media for the distribution of training materials are floppy disks and CD ROM. Which of them will be selected depends on the amount of data to be stored, the availability of drives and price considerations.

- **Computers interconnected into a computer network** immensely broaden the scope of applications. The most relevant new feature in comparison with stand alone computers is the interactive communication with humans or computers. The majority of on-line services can to a certain extent be used for training and teaching purposes.

- **In distance learning**, the electronic mail as the most frequently used service can provide for prompt contact and communication between trainees and tutors. It can also act as the media for the distribution of learning materials.

- **Usenet (News)** is a simple but very efficient system for communication among trainees. Its advantage is that, unlike electronic mail, questions need not be directly addressed to a known person. In this way we can organise supplements to informal discussions held in classes between the tutor and the trainees. As a result, the lists of frequently asked questions (FAQ), can be prepared as additional explanations of the most relevant topics. At the same time, important feedback information is thereby made available to the tutors and the authors of the course.

- **File transfer** is included in almost every computer communication protocol. It can be used for downloading course materials. Compared with the distribution on diskettes and CD ROM, changes in the courseware can be managed easier and faster and the use of the materials can be traced to a greater extent.

- **World Wide Web (WWW)** as one of the fastest developing Internet applications enables the construction and distribution of the on-line hypermedia course material. The Java and Java script support included in the most popular WWW browsers extends its functionality. The technical quality of the WWW courses approaches the quality of standalone courses prepared with special designing tools. It is suitable for DL whenever on-line courses and platform independence are needed. Its popularity is strongly correlated with the marketing potentials.

- **Many other on-line applications** are frequently used for training purposes, too. IRC (Internet Relay Chat) is an interactive text-based application which can be used for real-time connections between tutors and trainees. Some versions support real-time voice and video communications as well. In the environments in which groupware software is introduced for communication, collaboration and co-ordination, it's use can easily be extended to benefit training activities.

- **Finally, videoconferencing systems (VCS)** enable live, real-time voice and video communication. With this system it is possible to organise training and learning in situations where visual and audio communication is essential and thereby to overcome possible spatial barriers. Desktop and room videoconferencing systems in different quality and price ranges are available, and point-to-point, multipoint or broadcast communications, can be used for one-to-one or one-to-many duplex or one-way communications.
Actual implementation of a DL system can combine two or more of the available technical solutions. Which components will be included in our particular system will depend on our needs, the existing and planned hardware and software and communication networks. Other pertinent factors include the level of computer experience of the target trainee group and, finally, the price and profitability of a DL system.

Distance Learning System for Telekom Slovenije

Background
Telekom Slovenije is Slovenia's major telecommunications network operator and service provider. The company was established on 1 January 1995. It has about 3200 employees in nine business units located in different towns in Slovenia [see Fig. 1]. Telekom Slovenije provides the PSTN and ISDN services, data communications (X.25, leased lines, frame relay) and value added services (X.400 mail system, Slovenia On-Line, Internet access ...) and is currently a monopoly network operator in Slovenia. As legislation in this sphere is changing we expect other providers soon to appear in the free market environment in Slovenia.

The need to gain new and refresh the existing knowledge is enormous. In the sphere of telecommunications as the principal activity of Telekom Slovenije, the need for a change is particularly evident. For a prosperous future of the company the employees must develop professionally, but they are also required to keep pace with changes in some professional areas not strictly related to their everyday work. A broader outlook is essential to enhancing the flexibility of the company and its competitive edge in the free market environment. Moreover, Telekom Slovenije is passing through a phase of transformation and reorganisation which not only requires of its employees to follow changes in telecommunication technology and services, but also demands new knowledge in the domains like economics, project management, customer service and others.

Telekom's sphere of activity forces it to keep up with changes and new attainments in telecommunications, which makes training of the employees imperative. We therefore analysed the circumstances and possibilities for the implementation of a distance learning system as a means of training our employees. We also wanted to examine the possibilities for the use of similar or identical techniques as a basis of value added service, as well as the ways of offering that service to the market.

Figure 1: Telekom's business units in nine Slovenian towns

The project
Team
A project team consisting mostly of experts from Telekom Slovenije was selected. Since the project comprised a range of tasks we included in it experts in human resources, training, computer networks, the software and hardware and finance. The result of work of the project team was a proposal for a DL system suited to our needs. The proposal was concluded in September 1995 and preparations for its execution are under way.

Analysis of Training Needs
An important part of the project was the analysis of our training needs and the possibilities to use a DL system for the training. We sought those areas in which a larger number of employees need the same kinds of knowledge. As the existing job description and personnel structure offered only a fractional picture we were compelled to organise structured interviews with heads of centres in Telekom's business units, in which we analysed skill requirements in those centres. Basically, a structured interview consisted of questions about the needs for technical and general knowledge and about knowledge requirements of employees in the future. We processed the results so collected and classified the employees into groups by knowledge requirements. The classification was made primarily for the preparation of the distance learning system. The final result of the analysis was the identification of the fields of knowledge which the employees will need and which can be catered for by the system of distance learning, and determination of the scope of courses and number of participants by business units. The requirements for highly specialised areas of knowledge which are unsuitable for distance learning (too few candidates, too high a price of course preparation) were not taken into account.

Target External Users
Being a new challenge for both Telekom Slovenije and the users of existing telecommunication services, the computer and telecommunication supported DL will have to be introduced gradually. Potential external users will be acquainted with the capabilities of the DL system in order to analyse their training needs and the possible use of DL methods. The target external users of the distance learning system are individuals, enterprises and educational institutions. We identified three completely different marketing approaches contingent on the financial potential, the number of users and the hardware and communication equipment they have installed.

Individual users will have access to the system of distance learning over Slovenia On-Line system (Telekom Slovenije public information system). It stands to reason that users should be enabled easy access to the desired courses. It is true that user registration, authentication and login are vehicles which ensure good tracking of users and of the access to the contents, but too complicated access protocols may be repulsive. As concerns individual users, it would be reasonable to prepare cost-free selection of training courses (user has access to basic information about courses and selects his course) and even cost-free access to a part of the courseware or demos.

Enterprises could have access to the distance learning system in a similar way as individuals. It would be rational to offer a licence for the enterprise as a whole and the possibility of registration of individuals as members of the enterprise.

In the sphere of education, the use of the distance learning system would be a combination of access by individuals and access by enterprises.

Technical Considerations
In the technical proposal for the DL system we tried to include Telekom's existing and planned technical resources. The selection of the solution was influenced by several weighty considerations. Telekom Slovenije recently offered public ISDN service. The connecting of commercial users to ISDN is in progress whereby they are being capacitated for high quality switched digital communications at reasonable price levels all over the country. Secondly, for distance learning to be successfully launched as a value added service users must be enabled a uniform, simple and efficient access to the new service. These requirements are best met by the planned Slovenia On-Line system. It is a public, universal information system which enables uniform access over modem dial-up lines, ISDN, or packet switching data transmission network. Services which will thus be made available include electronic mail, videotex, banking transactions, Internet and Compuserve access and the like. Access to servers and, consequently, to client-server applications will be enabled. One of these applications could be distance learning and the server could be the one that Telekom will use for its needs. The Slovenia On-Line system will also contain service tariffing mechanisms. With the Slovenia On-Line system so designed Telekom Slovenije has been assigned the responsible task of becoming an Internet access and service provider. The
growing interest in Internet in Slovenia follows similar world-wide trends. Finally, Telekom has already started the planned reconstruction of it's computer network. When this project is completed all business units and, consequently, all the employees will have access to on-line services. The network will be used for internal communication, collaboration and coordination, but will also link these to DL resources and services.

Strategic Issues
When strategic issues are discussed, the areas like infrastructure (management and support system, performance measurement, building space, funding, etc.), marketing activities, learning support and access to learning and assessment have to be analysed. The size of the manpower available to us in the initial phase being limited, our solution had to be worked out with a minimum of personnel. It is impossible, of course, to organise a successful DL system by relying on computers alone. However, on-line applications offer a possibility to arrange the assessment, the support for the students or access to learning in a very efficient way.

Proposal for a Pilot DL System
During the preparation of the proposal the project team has reached the following conclusions concerning the current state of the needs, equipment and organisation of Telekom Slovenije and the desired state in the future viewed from the aspect of distance learning. The proposal is based on the analysis of training needs and target external users and reflects technical considerations and strategic issues.

The DL system will be introduced progressively, for the training of Telekom employees first. The introduction will take place in the pilot phase. For this phase of the project we were looking for a form of distance learning that would not be too demanding in economic and organisational terms and would enable us to include Telekom's experts in the preparation and operation of the system whenever possible. The introductory phase will bring us the necessary experience regarding the technical, management, support and organisational aspects and the use of the system.

We established that the most appropriate solution for the pilot project is a WWW based system, chiefly on account of it's platform independence, relative simplicity of implementation, it's popularity and functionality.

In the initial phase work will be based on computer courses (tutorials and formative tests). The basis of the distance learning system would be the earmarked WWW server which would be connected to the Telekom computer network. The employees will have access to the courses in the server from their PCs (clients) or from the PCs in business units set aside for distance learning. Many of the learner support activities can be included in the course material itself, as can the assessment. The advantage of WWW is that logs can be easily kept and analysed for each student and every course, providing prompt feedback to the student and valuable information for course evaluation to the authors.

One of the advantages of the WWW solution of distance learning is easy accessibility and favourable price of the software. The solution enables a relatively simple realisation of courses without the need to familiarise oneself with new program tools or languages (Telekom runs it's WWW server for other purposes, so we are experienced in HTML and C programming). The HTML is not the ideal solution for highly complex courses, to be sure, but the development of that format of recording is quick and, with Java support, holds out a promise of additional features in the near future. We believe that a number of appropriate courses could in this way be prepared and carried out at a favourable price of preparation. An important reason to decide in favour of an on-line system (and not e.g. CD ROM distribution) is that a copy of a diskette or CD ROM must be delivered to every user (or computer or network server used for training purposes). The contents of the course, once prepared and distributed, can hardly be changed. Tracking of the results of training after courseware has been delivered is problematical.

Hardware and software platforms and their management constitute the basis of a distance learning system. The key part is the content of the course available in the system. Theoretically, there are several ways of acquiring the tuition software which the analysis of Telekom's needs has indicated as necessary. There are many suppliers of various kinds of courseware in the world and one possibility would be to buy foreign teaching programs. In using them it is necessary to observe copyright legislation and conclude the corresponding agreement for each package. The purchase of foreign equipment entails other problems as well, above all the language problem, for courses
offered in the distance learning system must be in the Slovenian language. Moreover, the substance of these courses does not entirely suit our specific conditions. Such courses need to be re-written and adapted, not only translated, whereby the costs come close to the costs of creation of completely new courses. Therefore in the pilot phase Telekom will organise production of course materials. In the pilot phase we would invite Telekom experts to cooperate wherever such cooperation is possible. The work on the project task has shown that the proposed solution is optimal in terms of costs, too. At this point, we would like to draw attention to one of the most important results of the project work, notably the evident need for Telekom to try and establish comprehensive cooperation with other institutions in the area of the computer and telecommunications based DL. This cooperation should not be limited to the joint use of existing course materials only, but should also comprise cooperation in the production.

In the pilot phase we would start the preparation of courses in the domain of general technical knowledge (on ISDN, ATM, signalling No. 7, SDH, mobile communications, Internet, etc.) at the level of information about the topics concerned, occupational safety training and the fundamentals of human relations and communication. Instructions for the operation of Telekom computer network will also be prepared in the form of courses. We expect to prepare 35 hours of courseware in the pilot phase and to achieve about 30000 man hours of training within next three to five years. In making the selection of courses we were governed by the level of complexity of preparation and the suitability for use in distance learning, the possibility for cooperation with Telekom experts in the preparation of courses, and the number of users of individual courses in Telekom. The courses are from various areas of knowledge, the predominant being those offering instruction in telecommunications.

Conclusions - Implementation of the Pilot Project and Further Development

Our most important future plan is certainly the implementation of the pilot project which is planned to start in 1996. From the pilot phase we expect following results: The technical aspect of problems which the pilot system will be solving are associated with the hardware and software equipment, communication links and access to the server, and with the hardware and software of users. With the pilot project we shall gain the necessary experience in the management of a distance learning system, in other words we shall become familiar with the work with workstation, its operating system and the WWW daemon program. In this phase the operators will gain the necessary experience in operating the server and maintaining the required level of safety. We shall have a better picture of the kind and extent of management requirements (more accurate determination of workforce requirements) in case the need arises to expand the capacity of the distance learning system. The ultimate result of the pilot phase will be familiarity with the introduction and use of distance learning. Telekom employees will become acquainted with the new method of learning, and we would get real responses and thereby the opportunity to correct the courses, the system and the method of introduction. Once in operation, the system will also serve for presentations to prospective external users and their becoming acquainted with the possibilities it offers. The latter is fundamental to the accurate assessment of the number of other users, their interests and the possibilities for the marketing of the system.

We predict that in the future the system will be developing along these lines: Firstly, it will be necessary to complete other courses in those areas of our training activities where the number of Telekom participants alone is insufficient for the courses to be economically justified. We intend to invite other Slovenian enterprises and educational organisations to cooperate in the preparation and utilisation of these courses, and we hope to be able to form a base for a country-wide computer and NW based DL system. We shall gladly accept suggestions from external users for courses in new areas to also be launched. Secondly, the proposed solution for the pilot phase distance learning system does not rule out other solutions. Possible use of other telecommunications and computer services and applications will be investigated in greater detail. The use of videoconferencing systems seems to be among the most promising ones. Some interest in the use of ISDN based VCS for teaching and training has already been shown. Additional advantage of standard based VC communications is that the same system can be used for other purposes as well, business meetings for one, which makes the new investment easier to justify. Finally, Telekom's activities in the area of ATM, which will result in a test ATM based network, can be linked with DL development and can lead to the development of ATM applications in teaching and training.
References


Strategy for Setting up a Multimedia Resource Centre for Hungarian Universities

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Abstract: Five Hungarian Universities with a wide variety of teaching and research profile decided to set up joint multimedia development facilities to enable the staff members to develop interactive multimedia courseware for self-study centres and lecture room demonstrations. During the two year project a series of strategic questions had to be answered. The author, who lead the project lists a series of problems faced in the initial planning and implementation period and gives a set of possible solutions as the project management could see it. Some a posteriori experience also will be described.

1. Preliminary Information

The Technical University of Budapest, the Budapest University of Economics, the Eötvös Lóránd University, the University of Veterinary Science, the School of Public Administration in 1993 won a Governmental Project, also supported by the World Bank\(^1\) to create the technical and conditions and acquire the knowledge of developing interactive multimedia titles for teaching purposes. The relatively high costs of computer based teaching are compensated by the urgent need of increase in the number of University students and, improving the demonstration facilities of the Universities.

The project activities started with the enumeration and evaluation of those assets - hardware, software and know-how - which can be served as the basis for further developments. At the preparation and planning phase a substantial support from the multimedia consultants of the Bristol University (UK) was involved.

The participating Universities operate their Ethernet based LAN’s and three of them are connected via an FDDI ring, while the remaining two via leased telephone lines. At the non-computer oriented departments the dominating equipment’s at the user’s end are IBM compatibles, while at departments, involved in informatics teaching and research Unix workstations and Macintosh computers are also used. And, as it can be expected, full heterogeneity in the type and capacity. At the project start almost no software was available for sound, image or video processing, and no professional editing or authoring tools were used. At the same time, several isolated experiments were in progress aimed at the involvement of computers in the teaching process. A series of computer based lectures were developed in physiology, where the demonstration material was read from video discs, in anatomy, where simple hypercard technology was used to add interactivity to computerised lecture notes, and multimedia technology was an emerging research subject in a number of departments of electrical engineering.

2. How to deliver multimedia courseware - design of the user’s end

2.1. Playback facilities

At the very beginning of the Project it was decided, that in the centre of attention has to be placed the final communication between the students and the palyback computers, or display equipment. As a basic requirement it was accepted, that that the developed courseware should be displayed by the users on a computer equivalent to the Multimedia PC level 2, with optional MPEG-1 real-time decompression. As we have visualised the use of the developed courseware in self-study labs or on home computers, the application of more expensive playback

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\(^1\) Project No. FEFA 676
equipment was out of question. The data transfer rate of the double-speed CD-ROM is the limiting factor for video inserts. All moving picture objects have to be prepared in a way that the playback equipment can process a maximal 160x120 pixel size with 256 colours and 25 fps without special decompression (MJPEG or MPEG) but with enjoyable quality. This requirement is met by an MPC level 2 category computer.

While it seemed to be a good general solution to install only MPC level 2 computers at the user’s end, or upgrade the existing terminals to that capacity, it occurred that in a number of applications (e.g. histology) a 256 colour picture is too poor. It is also true however, that in those applications, where thousands of colours are necessary, moving pictures or complex animation are not. The playback of these titles does not put a high internal data transfer rate requirement between the CD-ROM driver and processor, in Windows-based applications a special graphic adapter hardware must be used.

The fact, that a 160x120 pixel size video can be hardly considered as an attractive movie, providing qualitatively more information for the students, than a pure text combined with still images, is also a commonplace. In most cases, when the video demonstration bears important information, or it has methodological function, at least a quarter screen has to be used. (A 1/8 screen movie draws the user’s attention sometimes only because it is annoying.) The conclusion is, that the user’s terminals have to be equipped with some kind of decompression facility, exceeding the capacity of the very popular decompression software, running under Windows or the Macintosh operating system. Without a dramatic increase in the processor speed (and price) no software decompression tools can provide satisfactory solutions. It was decided to apply hardware decompression. As soon as we are counting on the ever increasing number of user terminals, it is essential to keep the decompression price low even if the compression is relatively expensive or time consuming. The final solution is the relatively inexpensive MPEG decompression, performed by an additional MPEG decompression hardware. MJPEG, or other symmetric methods are more expensive, considering a small number of developing facilities and a large number of display terminals, as the compression function of the commercial hardware is not used by the students.

The final conclusion, drawn from the above analysis is, that for a number of courseware the basic MPC level 2 equipment has to be enhanced by a graphic adapter, enabling the display of thousands of colors and an MPEG decompression hardware. In several cases the additional hardware is not required. We have considered that the decision on the hardware addition has to be made locally, at department-level. Unfortunately, the necessary inhomogeneity in the playback equipment has to be taken into account at the courseware development phase.

2.2 Multimedia networking

An ideal environment for the use of multimedia courseware both in self-study centres and lecture room presentation is the “courseware on demand” system, where the users select the required title from the courseware library, stored on a multimedia server. Multimedia networking has a number of technical prerequisites, as servers with large storage capacity, a transfer mode, that corresponds to specific multimedia transfer requirements, e.g. adjustable Quality of Service (QoS) parameters to avoid frame loss during traffic peaks, and satisfactory transfer speed. At present, neither servers with very large storage capacity, nor transfer mode with adjustable QoS parameters are available. The Ethernet-type LAN’s at the participating Universities, and the connecting FDDI ring is unable to provide on-line multimedia service. As the substantial upgrade of the server computers and implementation of data transfer modes with QoS were far beyond the project objectives and facilities, the computer network in the near future will only be used for off-line distribution and downloading of the courseware. The Hungarian PTT is recently launching a pilot project for establishing an Asynchronous Transfer Mode (ATM) connection between selected users in the country, and the Technical University of Budapest and the University of Veterinary Science are among the first participants. But, within the next couple of years extending the ATM connection to a considerable amount of user’s terminals is unlikely.

2.3 Video conferencing

At present there are no videoconferencing facilities are established at the Hungarian Universities. There are however, several study situations, where both point-to-point conferencing and broadcasting can provide a substantial increase in the quality of teaching. Point-to-point connection between the self-study centres and teacher’s offices may provide an excellent media for on-line consultations if the students have questions while using multimedia courseware. Consulting by videoconferencing saves time for both the teachers and the
students, makes multidisciplinary study available with the concurrent involvement of several specialists in the learning process. Videobroadcasting through the network might be very effective for practical training, for example in veterinarian studies (animal surgery, etc.). Videoconferencing facilities might serve as well supplementary tools to interactive multimedia applications.

3. How to develop multimedia titles - a top-down approach

3.1 Local courseware development

Development of effective multimedia courseware even of moderate complexity requires a concentrated use of several resources. The most expensive resource of them is the time of the highly qualified teachers and that of the technical staff. The initial setup of the technical facilities, their localisation, organisation of operation have to be arranged in a way, that saves time for the teachers if they produce multimedia titles. There is strong similarity between software engineering and multimedia development. Each of them can be divided into planning, development, testing and implementation phases. In our experience the planning or specification phase where the project organisation of work, joint effort of the content area expert, the designer and technical staff can do the most for assuring the required quality of the output an minimising the total cost of the project in terms of time and resource utilisation. The most important issue in our opinion is to find a good compromise between the teacher’s vision about the product and the technical realities. We think, that only a general agreement on technically feasible standards - templates - can provide such a compromise. The templates must be supported by corresponding software tools. This fact of course has a very serious impact on the design and selection of the hardware and software authoring tools.

Due to the wide variety of subject areas and locations we decided, that the courseware development will be divided into two separate steps. The last step, which is the compilation of pre-processed multimedia objects, writing the text and incorporating interactivity into the teaching material has to be performed at the location of the participating teachers. We have assumed, that that the content area experts, in most cases the teachers of a subject have no programming skills, and their knowledge of computers is limited to the use of word processors, but they can easily learn how to use a high level authoring software with standardised templates. Consequently, hardware and software tools have to be implemented at the authoring locations.

3.2 Centralised media object development

The previous step of courseware development - provided the design of the material, or script has already been accepted - is the preparation of multimedia objects, as digital video sequences, sound files and still images. This operation requires specific hardware and software tools, and specific knowledge of computers. All constituents are expensive. Their effective use is possible only when they are concentrated in Multimedia Resource Centres (MRC), in our terminology. The following functions are collected in these MRC’s:
The separate and relatively distant location of the participating Universities lead to the necessity of setting up two MRC’s each one at the most distant locations. According to the local environment and facilities, there is a slight difference in the design of the Centres, with a greater emphasis on the delivery side at the Technical University and more input and processing equipment at the University of Veterinary Science.

4. Selection of hardware and software

4.1 Human factors

A frequent mistake in setting up new technical facilities is, when the knowledge, experience and motivation of the users are ignored. While in MRC’s we could count on the computer experience of the staff and their professional motivation, devoted cooperation from the content area experts can be expected only, when the technology is not absolutely new and not too sophisticated. At the participating Universities the teachers have a firm knowledge of desktop computers, they can freely use word processors and standard graphic interfaces. They can perform file operations and have the time and energy to learn icon oriented or object oriented courseware authoring, but not programming languages, or programming the courseware on a script language. Dramatic change of their computer environment would prevent them from developing multimedia courseware. The most general computer equipment of a non-computer oriented teacher in Hungary is an IBM-compatible or - less frequently - a Macintosh. As the great majority of the multimedia courseware is expected to be developed for non-computer oriented topic areas, the dominating type of equipment at the teachers disposal is an IBM-compatible, or in some cases a Macintosh.

The human factor in the case of the MRC’s is less important, as the staff of the Centers consists of well trained computer experts.

Unfortunately, the project period was too short to solve the teacher’s motivation problem. Developing high quality interactive multimedia titles is very time consuming, and there is no standard procedure to include the achievements into the evaluation or promotion process of the teaching staff. Only those teachers are willing to participate in this activity, who are driven by the idea of improving the quality of teching by new methodological tools.

4.2 Hardware and software

The technical considerations and the analysis of the human factors suggested us to select IBM-compatibles and Macintosh computers with high-level authoring software (Asymetrix Toolbook, Macromedia Director) as courseware development equipment for the teachers. As soon as the cost/performance analysis of this selection did not give a contradictory result when compared with larger computers, IBM-compatibles with Pentium processor and Macintosh Power PC-s were purchased for courseware development. The developing machines are connected to the respective LAN’s, equipped with CD-ROM drivers and sound processing hardware, but the basic configuration does not contain any specific hardware, like video-processing cards, or specific video overlay adapters. The basic software, implemented on these computers consists of the Asymetrix Toolbook MBT edition for IBM-compatibles, and Macromedia Director for Windows, or Macintosh computers. If local needs arise, the teachers can add still image processing and video editing tools, or they can use specific test- and evaluation-development software. It is also useful to obtain a simple object-oriented database management system.
The selection of the MRC’s equipment was less restricted. However, some basic limits were set at the very beginning. Of course, the first condition to meet was the limited amount of financial resources. The following landmarks were set after a thorough analysis of the objectives of the project and the factors described above:

The “no” conditions:

- The MRC’s should not be video-studios. Professional video-equipment is extremely expensive, and in our opinion there is no need to include long, professionally prepared video sequences into the courseware. Video inserts are used only for demonstration purposes rather than for entertainment.

- There is no need for sophisticated, professional video-editing software. Editors with two-three channels meet the requirements.

- There is no need of an expensive real-time MPEG compressor. The short video-inserts can be MPEG-compressed by software off-line in a few hours.

- There is no need for scanning large (A3 or larger objects). The most frequent still images to be used are slides, drawings on an A4 size paper, photographs, or computer generated pictures.

- There is no need for very high resolution, as the digitised object will be displayed on normal computer screens.

The “yes” conditions:

- All digitised objects have to be in standard format, compatible with the authoring software, implemented on the teacher’s computers.

- All digitized objects must be prepared in a form, which can be delivered on a multimedia level 2 computer

- All objects must be available through the inter-university network.

The above conditions and cost/performance analysis resulted in the following setup:

- A Macintosh Power PC-based video workstation, consisting of a Power PC/8100 with 72Mbyte RAM, 4Gbyte non-calibrating hard disk, Radius Videovision Pro board with SVHS and composite video-signal input, performing real-time MJPEG compression, and QuickTime (QT) output format, a computer controllable, high quality, but not professional video recorder and an additional monitor. The QT movie format can be easily displayed under Windows using the QT for windows software or translated into AVI format. As a video editing tool, the Adobe Premiere program is implemented on the computer.

- An IBM-compatible based image processing workstation with Pentium processor, 3Mbyte RAM, 1 Gbyte hard disk, a high quality A4 scanner with 600x800 physical dpi. For image retouche, and other processing needs the Adobe Photoshop and Illustrator programs are used. Until now we have not met any real image scanning and processing requirements, which could not be satisfied by this equipment.

- Two courseware development workstations, one of the is IBM-compatible, while the other is a Macintosh Power PC 8100. The IBM-compatible is equipped with the Asymetrix Toolbook MBT development system, and the Macromedia Director for Windows, while the authoring tool an the Power PC is the Macromedia Director for Mac.

- A test computer, which is IBM-compatible with a 486sx processor, 4Mbyte RAM and an optional MPEG decompressor board.

- An IBM-compatible computer with 486-type processor for CD-ROM writing.

All computers are connected to an NT server with 4Gbyte hard disk capacity. The NT server is a bridge between the MRC and the LAN of the University of Veterinary Science.
The configuration at the Technical University is slightly different from this. It includes a three-dimensional scanner, and the computers are connected directly to one of the University’s UNIX-based servers.

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How to Measure the Behavioural and Cognitive Complexity of Learning Processes in Man-Machine Systems

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Abstract: A framework to conceptualize measure of behaviour complexity (BC), system complexity (SC) and task complexity (TC) was developed. From this framework cognitive complexity (CC) is derived as CC = SC + TC – BC. A learning experiment was carried out to investigated the development of mental structures. Six subjects were carefully instructed to operate a commercial database management system (DBMS). The long-term knowledge about general DBMS- and computer experience was measured with a questionnaire once at the beginning of the investigation. On three weeks in a row all subjects had to solve the same task twice repeated in an individual session, overall there are six solutions of the same task. At the beginning of each of the three individual sessions the short-term knowledge about the task and the tool was measured with a short questionnaire. With the special analyzing program AMME the logical structure of each empirically observed task solving process was extracted. This logical structure is given as a Petri net. The behavioral complexity (BC) of this net structure can be measured with the McCabe-measure. With our framework the cognitive complexity (CC) can be derived from the empirically gained BC. The main results are: (1) The time structure and BC measure different aspects of the learning process; (2) the time structure is–overall–positively correlated with BC and negatively correlated with CC; and (3) as well the long-term- as the short-term knowledge has an increasing predictive power with the time structure, but not with BC and CC.

Introduction

We live in a dynamic and irreversible changing world. We are information processing systems and have a huge learning potential. What happens to humans, if they have to behave in an approximately static environment? If we need growth (in a psycho-dynamic sense) and development, how long we are able to tolerate contexts that fix and constrain our activities? There is a lot empirical evidence that humans are getting bored if the context is characterized by repetitiousness, lack of novelty, and monotony [Smith 1981]. Ulich differentiates between boredom and monotony [Ulich 1987]. Boredom emerges from the feeling of not having enough possibilities to be active. Monotony emerges from the feeling of doing always the same things. "Monotony is a consequence of standardisation of the work process" ([Ulich 1987] p. 8). On the other side there are allot research results of stressed and over-loaded workers.

We have to realize and to accept that humans do not stop learning after end of school. We are compelled to learn and to make experiences our whole life. Human information processing can not be independent of this life-long learning. In this sense, humans are open systems. In his law of requisite variety Ashby [Ashby 1958] pointed out, that for a given state of the environment, an open system has to be able to respond adaptively, otherwise the adaptability and the ability of the system to survive is reduced. A learning system, without input or with constant input, either decays or (in the best case) remains the same. Learning and the need for variety implies, that with constant variety of the context the requisite variety of the system tends to decay over time. This is a strong argument against 'one best way' solutions in work design (cf. [Ulich 1987]).

Activity and Incongruity

Investigators of novelty assume, that living systems (like humans) are motivated by an information seeking behavior. In situations, which are characterized by sensory deprivation, humans are intrinsically looking for stimulation. They increase the complexity of the context or the perception of it. On the other side, humans try to avoid situations with a
high amount of stimulation, dissonance, or stress. Hunt designated this amount of increased complexity as 'incongruity' [Hunt 1963].

If the complexity of the mental model ('cognitive complexity') is less complex than the complexity of the context (e.g., an interactive system), then humans try to optimize this positive incongruity [Rauterberg 1995]. Seeking behavior starts, when the positive incongruity sinks below an individual threshold or changes to negative incongruity (deprivation). Behavior of avoidance can be observed, when the positive incongruity exceeds an individual threshold (dissonance, stimulation overflow). Most of daily situations can be characterized by positive incongruity.

We shift the semantic and theoretic problems from incongruity to complexity [Rauterberg 1995]. Doing this, we can define incongruity in a more precise way. Incongruity is the difference of internal and external complexity [see Fig. 1]. Now we have to look for a good definition of complexity (see the discussion in [Rauterberg 1992]).

In man-computer interaction we are able to measure the complexity of human behaviour (e.g., explorative activities; see [Rauterberg 1993]). With some plausible assumptions we are also able to estimate the complexity of user's mental model (see [Rauterberg 1992]). The complexity of the context (the internal structure of the interactive software) can be measured.

Learning and Activity

Learning is a permanent process that changes our long-term knowledge base in an irreversible way. The structure of our long-term memory changes to more complexity and higher abstraction. The basic idea of our memory model is that the variety on one level can be reduced to the invariant structure. This invariant structure forms the next higher, more abstract level of learning. Learning implies abstraction. Humans under non standardised conditions evolve very abstract invariants during their lifetime. Learning as a driving force for irreversible developments is the most underestimated factor in human behaviour, especially in the work and organisational context.

Learning increases constantly the complexity of the mental model. This is an irreversible process. One consequence is, that the contextual complexity must increase appropriately to fit the human needs for optimal variety. Based on the empirical result in [Rauterberg 1993], that the complexity of the observable behaviour of novices is larger than the complexity of experts, we concluded that the behavioural complexity is negatively correlated with the complexity of the mental model. Thus it is possible to estimate the cognitive complexity based on the measurement of the behavioural complexity, the measurement of the system complexity and the measurement of the task complexity (for a more detailed discussion see [Rauterberg 1992]).

The Measurement of Complexity

The symbolic representation of the machine system consists of the following elements: 1. objects (things to operate on), 2. operations (symbols and their syntax), and 3. states (the 'system states'). The mental model of the user can be structured in representing: objects, operations, states, system structure, decision and task structure.
A net can be described as a mathematical structure consisting of two non-empty disjoint sets of nodes (S-elements and T-elements), and a binary flow relation (F). The flow relation links only different node types and leaves no node isolated [Petri 1980]. Petri nets can be interpreted in our context by using a suitable pair of concepts for the sets S (signified by a circle '( )') and T (signified by a square '[ ]') and a suitable interpretation for the flow relation F (signified by an arrow '->').

Bauman and Turano [Bauman and Turano 1986] showed, that Petri nets are equivalent to formalism based on production rules (like Cognitive-Complexity-Theory [Kieras and Polson 1985]). In this sense, our approach can be subsumed under 'logic modeling', too. Applying the path algebra approach of Alty to analyze the adjacency matrix [Alty 1984], we can get all "elementary paths in the network (e.g., paths which do not traverse an arc more than once). This algebra exhibits closure and the closure matrix gives all possible elementary paths between nodes" ([Alty 1984], p. 125).

The main operations (relations) between two Petri nets are abstraction, embedding and folding [Genrich et al. 1980]. The folding operation in the Petri-net theory is the basic idea of the approach presented in this paper. Folding a process means to map S-elements onto S-elements and T-elements onto T-elements while keeping the F-structure. The result is the structure of the performance net. Each state corresponds to a system context, and each transition corresponds to a system operation. This sequence is called a 'process' [see Fig. 2]. An elementary process is the shortest meaningful part of a sequence: (s') -> [t'] -> (s '').
Figure 2. Part of the interactive behaviour with a relational database system recorded in a logfile. The whole process of this example is based on 12 transitions and 12+1=13 states. The number on the right side is the 'time per keystroke' in seconds (s).
Description of the situation in Figure 2: The user's task was to search for a given data record in a particular file. He started correctly in the main menu (s0) and activated with the menu-option 'd' the module 'data' (s1). In the next step he activated with the menu-option 'b' the output routine 'browse' (s2). In this system state (s2) the user realized that an incorrect file was active, so he tried to change the active file by pressing the functionkey F3. This operation is normally correct, but only in the main menu and on the module level, not on the routine level. The system reacted with a help-message "Wrong input, press any key to continue". This message was incorrect, because only the functionkey F9 could be used to return. The system persisted in the 'wrong input state' (s3) and waited, until the user found the 'mouse-hole' F9 by trial and error. It is interesting to note, that the user went directly back to the main menu to continue his sub-task ('to change the active file'), although he could do this operation in (s1), too.

If the observable behavior can be recorded in a complete \( \ldots \rightarrow \text{(state)} \rightarrow \text{[transition]} \rightarrow \text{(state)} \rightarrow \ldots \) process description [see Fig. 2], then the analysis and construction of the net structure of this process are simple: You have only to count the number of all different states and transitions used, or to mark on a list the frequencies of each state and transition used in the process. But, if the observable behavior can only be recorded in an incomplete (e.g., \( \ldots \rightarrow \text{(state)} \rightarrow \text{[transition]} \rightarrow \text{[transition]} \rightarrow \ldots \) or \( \ldots \rightarrow \text{(state)} \rightarrow \text{(state)} \rightarrow \text{[transition]} \rightarrow \ldots \)) process description, then the analysis and construction of the net structure of this process are difficult. You have to find out the correct state (transitions, resp.) between both transitions (states, resp.). Unfortunately, this is the most frequent case in practice. For these cases we need automatic tool support. In the last years we developed a tool, that gives us the possibility to analyze any processes with an incomplete process description, that are generated by finite state transition nets.

The aim of the 'folding' operation is to reduce the elements of an observed empirical decision process to the minimum number of states and transitions, with the reduced number of elements being the 'decision structure'. Folding a decision process extracts the embedded net structure and neglects the information of the amount of repetition and of the sequential order.

A simple pattern matching algorithm looks for all 'elementary processes' in the sequence. A composition algorithm (the folding operation) is now able to build up the Petri net combining all elementary processes. The result of a folding operation of our example sequence [see Fig. 2] is the Petri net given in [Fig. 3.] This special net with four different states and nine different transitions is the whole net structure we need to produce the process given in [Fig. 2]. Measurable features of the behavioral process are: number of states and transitions totally used, number of different states and different transitions used, dwell time per state and transition, etc. These measurements can be easily done based on a protocol of the user's behavior automatically recorded by an interactive software program (the dialog system) in a logfile.

Figure 3. The 'folded' Petri net of the example sequence in Figure 1.
To measure complexity we use the Ccycle metrics of McCabe [McCabe 1976]. With Ccycle we have a useful quantitative metric to measure complexity. We are discussing the advantages and disadvantages of four different quantitative metrics in the context of an empirical investigation elsewhere (see [Rauterberg 1992]). The complexity measured with Ccycle is defined by the difference of the total number of connections (T: transition) and the total number of states (S: state). The parameter P is a constant to correct the result of Formula 1 in the case of a sequence (T - S = -1); the value of P in our context is 1.

\[
\text{Ccycle} = T - S + P \quad \text{[Formula 1]}
\]

The measure Ccycle of the example in Figure 3 is (9 - 4 + 1 = 6); the complexity of the net shown in Figure 3 is six. But, what could this number mean? McCabe [McCabe 1976] interprets Ccycle as the number of linear independent paths through the net. Other interpretations of Ccycle are number of holes in a net or number of alternative decisions carried out by the users.

Observing the behaviour of people solving a specific problem or task is our basis for estimating "cognitive complexity (CC)". The cognitive structures of users are not direct observable, so we need a method and a theory to use the observable behaviour as one parameter to estimate CC. A second parameter is a description of the action or problem solving space itself. The third parameter is an "objective" measure of the task or problem structure.

We call the complexity of the observable behaviour the "behavioural complexity (BC)". This behavioural complexity can be estimated by analysing the recorded concrete task solving process, which leads to an appropriate task solving solution. The complexity of a given tool (e.g. an interactive system) we call "system complexity (SC)". The last parameter we need is an estimation of the "task complexity (TC)".

The necessary task solving knowledge for a given task is constant. This knowledge embedded in the cognitive structure (CC) can be observed and measured with BC. If the cognitive structure is too simple, then the concrete task solving process must be filled up with a lot of heuristics or trial and error strategies. Learning how to solve a specific task with a given system means that BC decreases (to a minimum = TC) and CC increases (to a maximum = SC). We assume, that the difference (BC–TC) is equal to the difference (SC–CC).

To solve a task, a person needs knowledge about the dialogue structure of the interactive software (measured by SC) and about the task structure (measured by TC). SC is an upper limit for TC (SC>=TC); this aspect means, that the system structure constrains the complexity of the observable task solving space. Now we can state with the constraints (BC>=TC) and (SC>=CC), that:

\[
BC - TC = SC - CC \quad \text{[Formula 2]}
\]

Transforming this Formula 2 to get CC alone, results in Formula 3:

\[
CC = SC + TC - BC \quad \text{[Formula 3]}
\]

The parameters SC and TC can be estimated either in a theoretical or in an empirical way. The parameter SC is given by the concrete system structure, so we have to apply a given complexity measure to this system structure (theoretical way). The empirical way to estimate SC is to take the maximum of all observed BCs per task. To calculate TC all apriori descriptions of task structures are usable (theoretical way). If we have empirical data of different task solving processes of different persons, then we can estimate TC using the minimum of all observed BCs per task. Given a sample of different complete task solving processes, the best approximation for TC seems to be the minimal solution regarding a specific complexity measurement. One plausible consequence of this assumption is that CC is equal to SC in the case of "best solution" (TC=BC). This is the approach we are presenting here.

Results of a Learning Experiment

A relational database management system with a character-oriented menu interface was the test system. Six users (6 men; average age of 25 ± 3 years) had to solve one task in two different versions on three weeks in a row [Rauterberg and Aeppli 1995]. The difference between task-1 and task-1' was only on the formulation level ('task description'), but on the structural level both tasks were identically. The duration of the actual task solving session was about 30 minutes. Each keystroke with a timestamp was recorded in a logfile. Each user needed about 45 minutes for the
whole experiment (2 tasks, individual sessions). We measured the task solving time per task. Based on the logfiles we could measure the behavioural complexity (BC) with our analysing tool AMME (cf. [Rauterberg 1993]). To estimate the cognitive complexity [see Formula 3] we have to determine SC and TC. SC can be estimated as the maximum of all observed BC's (SC = 28). TC can be estimated as the minimum of all observed BC's (TC = 22).

The difference of the task solving time between task-1 and task-1' is significant (mean\text{task-1} = 9.5 ± 3.8, mean\text{task-1'} = 5.2 ± 0.9, F(1,10) = 15.3, p<.003). There is also a significant difference between the three days (mean\text{day1} = 8.6 ± 4.7, mean\text{day2} = 7.2 ± 2.9, mean\text{day3} = 6.3 ± 2.0, F(2,20) = 3.6, p<.045). The interaction term is nearly significant (F(2,20) = 3.2, p<.061; see [Fig. 4]).

Only the difference of the behavioural complexity between task-1 and task-1' is significant (meantask-1 = 24.3 ± 1.7, mean\text{task-1'} = 22.6 ± 1.4, F(1,10) = 12.7, p<.005). All other differences are not significant (see Figure 5). Only the difference of the cognitive complexity between task-1 and task-1' is significant (meantask-1 = 25.7 ± 1.7, mean\text{task-1'} = 27.4 ± 1.4, F(1,10) = 12.6, p<.005). All other differences are not significant [see Fig. 6].
In the first session ('1. week') the normally positive correlation between $t_{task-1}$ and $BC_{task-1}$ ($r = +.69$; $r = \pm .87$, and $r = +.80$) changes to a negative correlation between $t_{task-1'}$ and $BC_{task-1'}$ ($r = -.48$). This result is caused by one user with the most database experience who produced the most complex net ($BC=28$) in the shortest time (4.5 min). If we compare the correlation pattern of week-1 with the correlation pattern of week-2 and week-3 then we can observe a qualitative change from a positive to a negative correlation of the long-term and of the short-term knowledge with $BC$. We interpret this result as exploratory behaviour during the first session: the more knowledge, the greater the tendency to explore. Due to lack of variance for week-2 and week-3 the correlation between $BC_{task-1'}$ and the other measures can not be computed.

To get an overview over the development of the different influences of long- and short-term knowledge on task solving time and $BC$, we calculated all relevant correlations (collapsing task-1 and task-1'). The influence of long-term knowledge on task time is increasing from week to week ($r = -.02$ week1x1, $-.28$ week1x2, and $-.56$ week1x3). A very similar effect can be observed for the influence of the short-term knowledge about the task-tool mapping on task solving time ($r = -.06$ week1x1, $-.35$ week2x2, and $-.49$ week3x3). The measurement of the short-term knowledge about the task-tool mapping shows a high retest reliability (inter-test correlation $r = +.87$ week1x2, $+.86$ week1x3, $+.90$ week2x3).

Both–long-term and short-term knowledge–change from a positive to a negative correlation from week-1 to week-2 and week-3. If we assume that $BC$ is a valid measure for the amount of exploratory behaviour, then we can come up with the following plausible interpretation for this result: First, an exploratory behaviour helps the user to learn as much as possible about the system; during this first phase the long- and short-term knowledge enables and guides the exploration. After this first exploration phase the user can produce the minimal solution based on his new knowledge about the system. This interpretation could explain, why the correlation between $BC$ of week-1 and $BC$ of week-2 is zero and increases to a significant correlation between week-2 and week-3 ($r = -.03$ week1x2, $+.63$ week2x3).

**Conclusion**

Three different results are important: (1.) Our assumption that "learning how to solve a specific task with a given system means that $BC$ decreases and CC increases" seems to be correct. (2.) If all users reach the correct task solution (minimum of $BC$, see [Fig. 5]) then the variance between users disappear (see the columns of Task-1' of day-2 and day-3 in Figure 5). Furthermore, (3.) we can conclude form the empirical results that we must discriminate between the time structure (cf. [Johnson 1985]) and the logical stucture of a task. The time structure can be measured with the task solving time. The logical structure of a task can be extracted with our analysing tool AMME, and the complexity of this logical structure can be measured with the McCabe-measure. At day-2 all users learned completely the logical task structure (minimum of $BC$, no variance, see [Fig. 5]). Learning the time structure means to accelerate the task solving process. One psychological dimension of the time structure seems to be self-confidence in doing the right things at the right time.

**References**


Design and Operational Assistance of a Pedagogical Virtual Space

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Abstract: Tele-learning is really efficient but it may induce isolation. Teleconferencing is a powerful tool in a tele-learning environment to support collaborative work. But it poses some conditions such as the need for a moderator’s help. This is a difficult job because of the size of information. We propose a system called ACTIA to support the task of channeling debates, summarizing information, making the most of ideas and building knowledge bases out of concepts expressed during the debates. To do so, the system analyses and synthetizes the text of the teleconference.

1. Learning in a Pedagogical Society

Lifelong learning was never a vital concern in societies where techniques and know-how hardly ever changed in one’s lifetime. The individual’s continued learning scope was not greatly exploited nor was it a criteria as regards social and economic adaptability. Nowadays, the individual’s most important strength resides in his capability to learn, that is to say, to dominate, digest and transform information into knowledge and use it punctually and efficiently. This ability represents a determining factor of social adaptability as well as an critical measure of economic productivity.

The type of learning in question here is achieved most often without a teacher, outside the traditional training or educational structures. Everyone learns his own way and transforms information into knowledge. Everyone learns from others or, in other words, from those who feed the information networks. Thus, we learn from one another thanks to information feeding the networks. Technology is amplifying this process and shaping the information society into a pedagogical society.

Educational or training structures, --schools, universities, companies-- cannot be totally oblivious of the new social, economic and technological requirements brought about by the pedagogical society. They cannot stay indifferent to the resulting learning process. These structures are bound to evolve; they will have to implement new strategies and practices in order to prepare the individual adequately if he is to bring his own contribution to the pedagogical society. Trainers and educators have an important role to play in re-modeling educational structures. They must work to develop a pro-active, collaborative and self-managed learning model and attempt to optimize it through thoughtful use of technology.

In this perspective, research undertaken at Télé-university’s LICEF (Laboratoire d’informatique cognitive et environnements de formation), aims at better understanding collaborative learning. It also tries to promote collaboration within dynamic virtual environments where computer technology’s potential is used to support learning.

To introduce our research, we will first define what we mean by “pedagogical virtual space” and describe its components. Then, we will introduce the ACTIA system which is a technological tool designed to support the collaborative learning process in computer conferencing.

2. Definition and Composition of the Pedagogical Virtual Space

We define a pedagogical virtual space as an entity that is structured by the technological environment and where we can arrange various learning sites. In this space, technology’s potential is channeled to support learning. The technological environment is the main architectural piece and the sites support the realization of learning activities.
2.1 The Technological Environment: Technology Integration

The technological environment created by the LICEF’s researchers integrate three technologies: knowledge-based systems, multimedia systems and tele-informatics. This approach is intended specifically to support a learning process that is:
- non linear - that respects individual choices
- collaborative - that values peer support
- interactive - that allows communication among learners to connect knowledge and social and human values.

The environment comes to life through an interface called HyperGuide and its various tools intended for:
- Consultation: to explore, gather and process the relevant information;
- Free navigation: that permits each learner to adopt the methods suitable to his specific learning style;
- Support and advice: to accompany the student in his study project;
- Production: so the learner can consolidate his learning and present the results in original documents;
- Communication: to gather the trainer and learners through computer conferencing, to support collaborative work and anchor the socio-cognitive dimension of learning.

Except for computer conferencing, the proposed tools are used on an individual basis and result from a human-machine dialogue elaborated in a learning scenario that is prebuilt but adaptable.

Teleconferencing, on the other hand, features group discussion, exchange and work on given topics. Together, participants learn from a content still to be built and that they elaborate as they progress.
2. The interface, accessing the tools

- Navigation tools: Realization of learning activities
- Consultation tools: Access to documents and bases
- Production tools: Design and production of multimedia documents
- Communication tools: Exchange sites

2.2 Collaborative Learning Exchange Sites

In the virtual space, the teleconference facilitates the creation of sites to support group or team exchanges at a distance. It allows participants to communicate in a multilateral way, either in a synchronous or asynchronous mode. Messages may take various forms: textual, sound, visual or multimedia. Thus, groups of different sizes can meet virtually and enhance learning by accomplishing various activities: for example, discuss a specific theme (tele-discussion), transmit information (tele-presentation), solve problems and complete projects (tele-working).

The exchange places must be flexible enough to permit the free expression of ideas, opinions and information and the maintenance of egalitarian relationships. The freedom benefits the participants and stimulates their creativity, the circulation of original ideas and contents and the sharing of experiences that promotes meaningful and contextual learning.

Teleconferencing proves to be a powerful tool to support distance learning, especially in a collaborative perspective, but it poses some conditions. In effect, if we are not careful, the lack of attention to the communication process can lead to the production of messages that appear confused or irrelevant. Participants can quickly become submerged by an information overload. Messages will flow but they will quickly become unable to extract their real value, to retrieve or process them, in spite of their efforts. Moreover, the discussion might end up scattered, diluted, stretched and eventually extinct, should there be a lack of properly structured support and well defined objectives. That is why, to really benefit from teleconferencing, we must respect the two following principles:

1. Determine a specific vocation for the teleconferencing sites while designing them. This principle means designing or organizing the virtual space. We than insure a certain order in the exchange process by proposing a common frame that is understood by all.

2. Entrust the animation of teleconferences to a competent moderator. The moderator’s role consists in helping the group reach its goal and improve its performance.

3. Organization of Exchange Sites that have a Specific Vocation

The contents analysis of several teleconferences has led us to identify four types of messages:

- social and emotional: acts as a cohesion factor within the group;
- cognitive and metacognitive: relates to the task undertaken by the group;
- organizational: used to transmit guidelines and take decisions about the task or goal to achieve;
- technical: concerns problems related to the use of technology.

We have noticed that when these various types of messages are not directed to distinct teleconferences, the exchanges become rapidly confused, communication appears less efficient and the group becomes less
productive. We suggest to specialize the exchange sites on the basis of message types in order to maintain communicational homogeneity within a conference and to optimize the general efficiency of the exchanges.

3. Exchange sites

<table>
<thead>
<tr>
<th>Tools</th>
<th>Group or teamwork teleconference</th>
<th>Electronic mail</th>
<th>File transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socialization, affectivity</td>
<td></td>
<td>Duo</td>
<td>One to one</td>
</tr>
<tr>
<td>Technical support</td>
<td></td>
<td>Interest group</td>
<td>One to many</td>
</tr>
<tr>
<td>Ressources and task management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussion, reflection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task execution</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There must be a particular site designed to accommodate each type of message. Thus, in the virtual space, we find specific teleconferences to:
- socialize and express emotions;
- offer or ask for technical support;
- facilitate the management of group activities;
- explore learning topics and discuss them;
- accomplish the collaborative task.

In the participants eyes, the teleconference that is task oriented seems to be the most important. However, the planning and design of other types of teleconferences should not be minimized. Ignoring the need for informal and social sites, for a place to ask technical questions or a site specifically named to address matters pertaining to group regulation and support can seriously handicap the efficiency of the communication process and the quality of messages. The absence of other vocational sites will quickly lead to an information overload within the teleconference that was originally intended to be task oriented. It will also affect negatively the group performance and possibly cancel the learning potential.

4. Animating the Sites

Just like in face to face situations, teleconferencing meetings benefit from the leadership of an assembly president, an animator, a moderator or any other person whose role consists in helping the group reach its goal. In effect, each virtual space should have its own moderator to support and regulate the debates. In the context of a collaborative learning situation, the moderator’s role is one of facilitator’s. His presence should be geared to nurture or stimulate the dynamic process that occurs within the group, to see to the smooth functioning of the social process and to insure the required cognitive support in the exchanges related to the knowledge contents discussed. The moderator must analyze each learner’s contribution, evaluate the group performance, establish a diagnostic of the problems. This will enable him/her to implement the proper intervention strategy.

5. The ACTIA System

The moderator’s task rests on a specialized know-how that cannot be improvised. The ACTIA system has been developed to assist him in his work. It is a user-friendly tool that will help him:
- Determine which types of conferences are suitable in view of the group’s proposed learning activities;
- Plan and adjust his interventions.
ACTIA supports teleconference analysis, diagnostic help and the building of knowledge bases. Data obtained through the process of teleconference contents analysis serves to produce instant flashes of the action, particularly as regards group dynamics, discussion coherence, pertinence of the interventions and participants’ performance. It is also a means to recover and organize the knowledge generated.

ACTIA processes the teleconference as text even though it is actually much more than a simple written text. If we look at the text aspect of the teleconference, we see that it is composed of messages bearing a certain form and contents. The contents of a particular teleconference may be examined through various angles, such as:
- Who talks (the writer of the message)
- What is said about a specific theme (the knowledge contents)
- How it is said (the exchanges)
- What strategies are used to say it.

To illustrate the participants performance, ACTIA can generate results from a variety of points of view. It concerns essentially the interaction, the relevance and consistency of the exchanges. After coding the messages contents using simple screens, we may then recover, among other things:
- Quantitative data concerning various categories of interventions
- Quantitative data concerning the originators: the number of interventions by author, among several authors, at different times and about various discussion themes;
- Maps of the interaction that show the links between messages;
- Maps of the interaction that shows the links between authors;
- The average profile of one individual’s or group interventions ;
- The percentage (distribution) of the participants interventions in the teleconference;
- The correspondence rate between individual or group messages and one or several ideal example messages;
- A participant’s contribution to the knowledge base.

With ACTIA, it is possible to extract an archetypal message. This helps the moderator locate the group’s as well as individual strengths and weaknesses and quickly identify extreme cases. Furthermore, the exchange maps that illustrate the links between messages and/or authors allows us to draw a global portrait of the interaction. These maps track down the particular messages that trigger the interaction and their authors. Combined with the analysis of the actual text, they reveal the participants thematic interests or concerns and clans shaping up within the discussion group.

The moderator will need to be trained to formulate requests that are relevant so that the results can be exploited strategically. He will proceed in successive steps: first, he will develop a feeling about the ongoing conference and the authors performance; then, he will try to identify the problems. From these initial results, the moderator will retain the aspects he wishes to examine in further details and he will undertake a more precisely targeted search in order to formulate a precise diagnostic. Hence, the moderator who uses ACTIA while the conference is in progress, will uncover facts that are liable to guide his own approach of the group or one individual.

As regards ACTIA, the moderator also plays the role of cognitician: he will have to code the knowledge contents that emerge and will have to integrate them in a knowledge base. As a result, the participants will be able to handle information more easily and re-use the knowledge contents as they see fit. Retrieving and organizing the knowledge contents must be possible globally or individually.

Then, once the system is completed, the participants would have the opportunity, from one teleconference to another, to develop their own personal base which will eventually become a knowledge tank closely linked to their interests and concerns.

Conclusion

ACTIA supports the teleconference moderator in the task of channeling the debates, of making the most of ideas, in synthesizing the information, in supporting and evaluating the participants. After determining strengths and weaknesses, in terms of interaction dynamics, coherence and relevance of the interventions, the moderator becomes more knowledgeable and can help the learners to better manage their participation and make the most of it. Consequently, in designing ACTIA to help diagnose performance, our goal is to bring the largest number of users to develop these specific competencies that are required in a teleconferencing environment. Thus, ACTIA
is a tool that can contribute to make better users who are better equipped to exploit the potential of teleconferencing, especially within a collaborative context.

Improving teleconferencing abilities means that we have to train users so they can improve their communication skills, share information and knowledge coherently and adequately, work within a group or team to accomplish common tasks and, through this collaboration, learn more efficiently and in a more meaningful manner. We believe these skills represent key elements in the fundamental competencies required in the information society. These specific abilities are now becoming a point of reference in relation to ourselves and others, that is to say, the mental power required to visualize and understand virtual space, the autonomy necessary to take productive initiatives and collaboration to optimize learning and the human potential.
Revising An Environmental Information Database Using Interactive Multimedia Technology

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Abstract: Publishing professionals and scientists at the Department of Energy's Savannah River Site combined efforts to create a multimedia database summarizing more than 40 years of ecological research on the site. The original Environmental Information Database, or EID, was a 2000-page document containing a lengthy text, many tables, graphs and monochrome illustrations. Its purpose was to convey research data to ecologists, government officials, and the public. Using CD-ROM technology, the budget which formerly produced fifty printed copies of the EID now can produce five hundred copies on CD. With this ten-fold increase in productivity, summaries of valuable research data that had previously been buried in hundreds of scientific and technical publications dating back to the 1930's are now available to a much wider range of audiences. The CD-ROM medium also enables the use of videos, scientific animations, and a vast library of color photographs, making the EID's huge volume of information more accessible by managers, specialists, and students. The Westinghouse Savannah River Company (WSRC) Multimedia and Internet Production Group increased the types of data in the document, and redesigned the computer interface to make access to the EID easier for people who are not scientists. The CD-ROM edition of the EID has many attractive new features, including a multi-level keyword index, a browse mode, and hundreds of hypertext links.

Introduction

During an enterprise wide reorganization in 1994, Westinghouse Savannah River Company's Management Services Department formed the Multimedia and Internet Production (MIP) Group to take a new look at the familiar and often burdensome task of producing reference documents for scientists, managers and federal regulators at the US Department of Energy's Savannah River Site (SRS) in South Carolina. The EID was chosen as an ideal candidate for conversion into electronic multimedia because it is a large reference work that is underutilized by its primary audience, the ecologists and environmental research scientists at the SRS. In undertaking this challenge, we hoped to establish electronic multimedia publishing as a cost effective option for information distribution, and the success of the EID on CD-ROM has amply justified that hope. This experiment has proven that electronic publishing is cost-effective, and that it can actually generate new audiences for technical information, and new opportunities for WSRC.

Every two years, ecologists at the SRS have received an updated edition of the EID, which has become a standard reference document. The EID is in two volumes, comprising over 2000 pages of text, maps, and line art, and nearly half a century of detailed ecological study over a 300 square mile area in the Central Savannah River Area between Georgia and South Carolina. Early in 1993, a strategic self-assessment conducted by the WSRC Management Services Division revealed that the EID was reaching its intended audience, but was frequently overlooked by the ecologists, and largely unknown to other scientists on and off site. We concluded that producing and distributing the EID on interactive CD-ROM would save time and money, satisfy more customers, and prove an important concept that could be applied to future jobs.

An "Electronic EID" would:
1. merge two separate volumes into one seamless document
2. reduce the final cost of each copy by about ninety-five percent
3. enable the publications group to comply with federal guidance on conservation of energy and paper
4. reduce the amount of labor involved in production and revision
5. exemplify the environmental benefits of electronic publishing by reducing local consumption of inks, solvents and power, and thereby show compliance with federal mandates to reduce toxic wastes generated by ordinary printing methods

6. offer audiences unprecedented and valuable features, such as full text searching, an comfortable interface, and hypertext navigation

7. offer editors an opportunity to reconstruct the EID to assure closure of each topic

8. enable scientists to use video summaries, color photograph library, and color figures as audiovisual aids when conducting seminars or addressing public meetings

Design Considerations

The reworking of the EID into a multimedia product was essentially a "proof of concept" effort within WSRC's Administration and Infrastructure Division, and therefore became the focus of every expert in the MIP group. This convergence of expertise led to the identification of three categories of program characteristics. The first of these, information already in electronic form, comprised text and line art formerly included in the printed editions of the EID. The second category, other essential information and attributes, comprised audiovisual elements formatted as QuickTime video files, audio (sound) files and digitized photographs, and fundamental program features such as one point of access for all data, navigation features, multiple user platform compatibility, true hypertext links between photos, text and art, and the addition of color to the formerly black and white EID. The third category, other "nice to have" information and attributes, comprised many informational elements and control features that had to be produced specifically for the multimedia EID project, including illustrative animations for scientific visualization, full-text search capability, and comprehensive electronic cut and paste capability. This last feature was aimed at users of the EID's extensive academic references and enormous photo archive, who might extract this information from the EID while preparing their own research publications.

Choosing the Right Tool for the Job.

When it came to selecting the software tools for transforming the EID into multimedia hypertext (hereafter called "hypermedia"), the MIP group had to re-examine its role as an organization in the company and within the federal nuclear complex. Our strategy for maturing from the traditional paper and ink paradigm to a networked hypermedia model was to sustain our conventional publishing role while retooling for electronic publishing. This approach demanded selection of software flexible enough to process the site's vast amount of archived text as well as recently digitized media. The software tools which were commercially available for this purpose may be classified into three types, each possessing desirable qualities for multimedia applications directed toward a wide audience. This made selection of an "authoring" tool for the EID critical, resulting in an exhaustive analysis of product features plotted against user expectations. The three software products below typify the general qualities found in the many similar products analyzed by the EID design team.

Cross Platform File Translator (Adobe Acrobat)

This product met the design criterion for cross platform text based applications, but was not selected because it does not permit document corrections after hypertext linking is completed. It also failed to provide certain basic interface and audiovisual features, such as pop-up menus and QuickTime compatibility, and lacked master page linking features.

Interactive Multimedia Browsing Tool (Hypercard)

This multimedia tool provided many of the user interface criteria required by the design team, but proved to be problematic in two vital areas. First, implementation of the multimedia EID in Hypercard would have required an extensive reformatting effort to convert the SRS's vast archive of text and line art files. Secondly, assuming the reformatting could have been done in a timely and efficient manner, Hypercard's complex programming language was deemed unsuitable for authoring the comprehensive search logic described in the design team's script.

Multimedia-Capable Publishing Software (FrameMaker)
The design team identified a desktop publishing software product which satisfied all basic mission criteria. FrameMaker, created by Frame Technology Corporation, can quickly reformat our original text files, allows corrections up to the last minute, supports all key elements and master page features, employs a simple scripting language, supports cross-platform file capability, and, perhaps most importantly, is produced by a company which is sensitive to the needs of its customers. Despite their recognition that our application's design was at or beyond the performance envelope of FrameMaker, the vendor cooperated to help us achieve our goals.

Data Development

Working from the latest edition of the printed EID, the design team, together with SRS ecologists, developed content for the hypermedia EID. Fortunately, the publication of the EID is a regular and iterative process. This minimized the need to edit existing text, tables, and figures. As the designers began the task of tagging and linking the content as hypertext, communications professionals were organized into a media production team to support the design team with new content, specifically intended to exploit the powerful multimedia features in FrameMaker. Graphic artists colorized most of the existing EID maps to increase legibility. Video and photos, much of which existed in site archives, were located, matched to otherwise purely textual segments of the EID, and digitized for hypertext linking by the design team. It is significant to note that the media production team opted to use existing audiovisual media whenever possible, in order to reduce or eliminate costs associated with video production and photography. In fact, less than ten percent of the electronic EID's total audiovisual content was newly generated material, and in those few cases, video scripts were extracted verbatim from the existing EID text files. This simple procedure eliminated the normally lengthy delays associated with gaining approval for release of new information to the public. Another potential barrier, acquisition of video production support, was evaded by the production team when surplus industrial video equipment was recovered from salvage depots and returned to use in support of the EID project.

Structuring the Data

As the production team was discovering what their surplus and rather well-used A/V equipment would do, the design team labored with site ecologists to convert the linear, text based EID into a hierarchical interactive hypermedia tool. What follows is a brief outline of the steps they took to achieve this conversion.

Decide the Purpose of the Information Document.
The hypermedia EID was meant to expand the usefulness and raise the intrinsic value of the information in the printed document. In designing the user interface and supplementing the text to appeal to non-technical users, the MIP group was targeting new audiences in educational and regulatory institutions.

Define the Document's Major Sections.
In consolidating a lengthy technical document for interactive random access, it is important to limit user options to no more than six at any point in the knowledge hierarchy. Doing so simplifies the linking and programming tasks of the designers, and simplifies user navigation, too.

Clearly Define Each Contributor's Authority and Responsibility.
In compiled technical documents such as the EID, expert authors frequently disagree, because scientific disciplines can create conceptual barriers that are irrelevant to Nature. For instance, a tree expert may argue with a bug expert over the proper representation of a bark-eating beetle. The design team avoided such disputes by officially authorizing one expert within each subject module. This tactic also improved "team spirit" between the scientists and the MIP group, because the scientists knew that they were responsible for the accuracy of the finished product.

If It Isn't Verified Data, Delete It.
The design team chose to exclude all data which could not be verified. Since research literature can be speculative and digressive, we assumed that users who needed such detail would not be averse to retrieving the actual paper from a technical library. To facilitate this, a full bibliography was linked to each text module and included with the other indices.
Add subject headings as needed for program flexibility.
Assembling documents from different authors, times and disciplines forced the design team to remain flexible in the EID information hierarchy. With its template based construction paradigm, FrameMaker was able to accommodate extra information flows and new menu items as required for every subject heading.

Realize that one paragraph may not lead or relate to the next.
Individual EID users apprehend information in personal styles that can only be characterized broadly. Since it is likely that not all of the information provided by a researcher pertains to a given user query, effort was made to link concepts treated by several authors by using hypertext. The added audiovisual dimensions of the hypermedia EID greatly facilitated this process, enabling such links to be fortified with photographs and scientific visualizations formerly unavailable to the EID primary audience.

Create Templates to Regulate the Size and Location of Figures.
The value of electronic document construction templates deserve special mention for two main reasons. They relieved the hypermedia production team from the tedium of assembling the navigation buttons, text windows, audiovisual media displays and background mattes in each frame of the program, and they preserved the character of the user display, which created a more comfortable user environment.

Index Every Feature and Subject, Then Index the Indices.
There are browsers, and then there are users who prefer ordered indices for each data type in a document. The hypermedia EID is designed to appeal to both types of user. This design attribute was made possible by the hypertext links assigned to the technical terms within the EID, and contributes to the high quality of the electronic EID.

File Management

The techniques for maximizing CD-ROM performance in a large scale publishing effort like the EID are now generally known, but in 1993 the MIP group was engaged in breaking ground for progress in hybrid (Windows & Macintosh readable) CD-ROM production and random access document design. The valuable lessons that we learned in our achievement now seem like common sense, but they deserve to be repeated: (1) keep document files small - approximately one megabyte; (2) use only photographs which offer high quality displays after digitization; and (3) modify video capture and display specifications to effect optimal data transfer rates from CD-ROM.

What Will Fit on a CD-ROM

Given a totally recorded CD-ROM holding 660 MB of information, you can fit 200,000 text pages, or 30,000 images, or 120 minutes of video, or any proportional combination of these data types, onto the disc. However it should be noted that, with the exception of large multimedia documents such as the EID, the full capacity of the recordable CD-ROM is seldom used, and such thorough use is becoming rarer as recording technology improves and the cost of therecordable media drops. The hypermedia EID contains the equivalent of 2000 printed pages, over 200 photographs, over 400 figures, over 400 tables, 27 content related video segments, and an instructional video segment to familiarize users with the tools for navigating the database.

Details of the Hypermedia EID Project Plan

The labor cost of producing the hypermedia EID can best be understood by asserting that the cost of conventional paper and ink production equals a given number of hours. The conversion of the original EID into the hypermedia version required three months of additional effort. The additional time was distributed among specialists and support personnel, including the project manager, an editor, a video producer, a photography coordinator, and three typesetter/compositors.
CD-ROM Replication and Mailing Costs

The tremendous advantage of electronic publishing over hard copy techniques is most clearly expressed in comparing replication and distribution costs. The EID project, despite its limited (under 1000 copies) circulation, lowered the overall cost of delivering the information to the user by an order of magnitude. 500 copies of the hypermedia EID on CD-ROM cost approximately $2500, while only 50 copies of the paper edition had cost $2250. Incredibly, the direct cost to the user for the entire enhanced database on CD-ROM is below the cost of merely the loose-leaf binders for the paper edition! The breakdown of CD production costs for the EID project is:

1. $1000 to generate a metal master and produce a "stamper" from which the CD-ROMs are made
2. $1000 for the first 100 CD-ROMs
3. Roughly $1.17 per disc for each additional 500 CDs (thus a 600 disc production run yields an end user cost under $5.00 per unit)

What Did We Learn?

The hypermedia EID has succeeded in accomplishing several strategic and tactical goals of the MIP group and the WSRC Publications Department. The undeniable cost advantage of electronic distribution has heightened awareness of electronic publishing throughout our company, and has won a new appreciation of the expertise needed to produce successful multimedia programming. The EID CD-ROM is also generating follow-on projects, which promise to extend the technological leverage of multimedia and network publishing beyond the scientific and archival applications that once were the main justification for such efforts. Growing demand for the EID CD-ROM from the site ecology laboratories indicate that it is a viable, and often a preferred, alternative to the paper document. Perhaps more significant is the fact that, without any external publicity, dozens of requests for the program were received from local legislators, educators, and citizens' groups. The MIP group sees this unprecedented interest as proof that multimedia can add value to technical information, and that investing in such an effort will stimulate new audiences to request and use information that the United States Government and private industry has collected. In satisfying its primary, scientific audience, and by awakening new audiences, the EID CD-ROM has created a favorable environment for increasing the work flow of the MIP group in two areas: (1) continuing and accelerating the reclamation or "re-purposing" of existing information, by reusing the templates and general characteristics of the EID ("cloning" it's attributes onto other databases), and (2)designing alternative models for distributing other, newer forms of scientific and technical information. Recent developments of HTML (Hyper Text Markup Language) utilities for FrameMaker and other word processing software enables the MIP group to publish through the Internet whatever unclassified information would be of interest to the public. Such documents could be composed using either standard desktop publishing and pre-press software applications, or document mark-up modules which have emerged to fill the growing need for rapid construction of sites on the World Wide Web.

Our Future

The MIP group profits from the lessons learned during the EID project in the following manner: we gather and create data for the electronic and paper versions of a customer's document simultaneously; arrange the mastering and replication contracts early in the document's life cycle; and allow ample time for quality control testing. As we publish more reference books on CD-ROM, we will strive for "seamless integration" between separate publications by applying hypertext tags. We also expect to continue increasing the value of documents in our archives by combining parts of them with new works. The resulting documents will address completely different purposes than those of the original works, and will exemplify a new publishing paradigm; managing information as data instead of as books or pages. Conference proceedings, for example, comprising full text of presentations along with video clips of the presenters and colorful graphical indices, are just one of the MIP group's new multimedia products. Several other new products are envisioned, such as teaching aids, multimedia enhancements to organizational procedures, job aids, and maintenance instruction systems.
New Technologies

Redefining the information management process to take advantage of electronic publishing has also expanded the potential role of other new technologies. Wireless networks, World Wide Web sites, "personal digital assistants", desktop videoconferencing and full screen video on CD-ROM are just a few of the technologies that are shaping the future not only of the publications department, but of the company itself. Formerly esoteric disciplines such as artificial intelligence and virtual reality will blend with mainstream product lines as companies seek to extract the greatest value from their information holdings, their one true source of wealth. As the current organizational trends of down sizing and flattening spread through our economy, and as efforts to meet specific demands from more customers increase, information management technologies will appear with increasing frequency on business planning agendas throughout the company, the nation, and the world.

Conclusion

As the twenty-first century dawns, electronic publishing on CD-ROM and through networks such as the Internet has emerged as an attractive alternative to the traditional paper and ink model of information management. Despite the growing abundance of expertise in this field, electronic publishing is still an infant technology, constrained by twentieth century paradigms. And like any immature technology, it can be troublesome and expensive, since it forces us to re-think the fundamental ways in which we use information. If corporate and individual information holders can recognize the transitional nature of the CD-ROM medium and the Internet, and learn to exploit these media and their successors, then these difficulties will be temporary and brief, and great advances in publishing economy and efficiency will result. Information holders who wish to reap the maximum benefit from these technologies must investigate and employ new organizational strategies, information management paradigms, and design skills.

Characteristics of effective electronic publishing strategies include: (1) detailed project plans, (2) application prototypes which are critiqued early and often in the development cycle by a random sample of the target audience, (3) quality control plans which effect rapid, reliable and accountable modification of electronic documents, (4) adherence to acknowledged standards of nomenclature, program logic and design, (5) clear administrative controls over intellectual property, copyright and contractual issues, and (6) regular, detailed product testing. The MIP group is using the lessons learned from the EID project in such a way that, each time a multimedia project enters our work flow, less effort is needed to design the application and to persuade the customer of the benefits of interactive or multimedia communications. Continuously refining our process ensures that the value we add to our customers' messages will continue to grow, enabling us to anticipate and plan for inevitable variations in schedules, technologies and methods.
First Amendment Rights and the Internet in K-12 Schools: Legal Precedent from Print Media

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Abstract: U.S. Supreme Court rulings on first amendment rights in schools provide precedent for the extent to which schools may control student usage of the Internet. The first amendment rights of students may be waived if the speech is disruptive or if the student signs an Acceptable Usage Policy document. A school may not remove material in the library, which may include a digital library as well, without extenuating circumstances. A school has the power to restrict information in order to “inculcate community values” but that duty does not extend to non-compulsory domains such as school libraries or possibly extracurricular Internet usage. The public nature of the Internet impedes the right of schools to restrict student speech; however, schools may restrict speech that bears the imprimatur of the school, possibly including email messages and Web page accesses in which the school’s name is recorded.

Introduction

Despite their late entry into the Information Age, K-12 schools are connecting to the Internet and other networks at a fast pace. Schools are using the Internet either in place of or to complement traditional media. Teachers supplement required textbook readings with information acquired on the Internet. In school libraries, students connect, via the Internet, to a vast collection of on-line books and magazines in digital libraries. Students are increasingly publishing school newspapers on-line through the World Wide Web, rather than printing and distributing copies on newsprint.

As computers and networks spread within the schools, principals and administrators are uncomfortable with the lack of controls over the flow of information within and outside the school. Traditionally, schools have exercised rights to restrict somewhat the texts used in class, the books found in school libraries, and the articles published in school newspapers. As the Internet is used in the school as a textbook, library or newspaper, school officials will seek to exercise control or censorship of the network. Historically, the courts have drawn a delicate line between the rights of students to receive information and to exercise free speech and the rights of schools to restrict information that students send and receive. Supreme Court decisions have drawn a different line based on the medium. This practice is consistent with the varying legal protections media have historically enjoyed as described in [Pool 1983]. In the case of textbooks and school newspapers, school authorities have a greater right to regulate the information flow in, out and within the school. School officials have much less power to censor library materials once they have been acquired by the school.

Student rights to Internet usage have yet to be scrutinized by the courts. For the purpose of school control, should the Internet be viewed as a textbook, library, newspaper or something wholly new and revolutionary? The extent to which legal precedent from print media is appropriate for the Internet must be determined. These issues can be examined in the context of the Federal court judgments on first amendment rights of students in schools. The extent to which freedom of speech applies to the Internet should then emerge.

The Right of Parents and the State to Protect Children

The First and Fourteenth Amendments protect the rights of Americans to free speech. However, since these rights were put to paper, the courts have acknowledged that they are not unconditional, but rather presuppose accompanying responsibility. As will be discussed later, the courts have determined that children inherently have less right to unrestricted free speech. Children’s rights may be even further restricted in a schoolhouse. Decisions of the courts have defined the extent to which children can exercise free speech in a school environment.
In 1923, the U.S. Supreme Court adjudicated Meyer v. Nebraska (262 US 390), in which the right of the State to prohibit the teaching of certain subjects was put in question under the Fourteenth Amendment. At the time, state law in Nebraska prohibited the instruction of any language other than English (excluding “dead” languages such as Latin, Greek and Hebrew) to students who had not completed the eighth grade. In 1920, a school teacher named Meyer was convicted of violating this law when he taught German to a ten-year old child. After the Nebraska Supreme Court affirmed the conviction, Meyer brought the case to the U.S. Supreme Court under the claim that the statute “unreasonably infringes the liberty guaranteed to [him] by the Fourteenth Amendment.” (Id. at 390.)

In Meyer v. Nebraska, the Court took an important stand on the relationship among parents, children and schools. In the opinion delivered by Justice McReynolds, the Court asserted that “it is the natural duty of the parent to give his children education suitable to their station in life.” (Id. at 400.) The opinion made the assumption that the school acts as an agent of the parent while the child is in attendance at school. As an agent of the parent, the “power of the State...to make reasonable regulations for all schools...is not questioned.” (Id. at 402.)

While the Court stood firm on the rights of parents and schools to control the education provided to children, it did not give them unconditional power. The court strongly stated that the State must respect “the fundamental rights” of the individual. It is unclear, however, whether this statement applies to the rights of the teacher or of the student. It is likely that the rights of both were affirmed. In its ruling, the Court determined that the teaching of German was not “clearly harmful” and therefore the State statute was unconstitutional. This ruling implied that the State may restrict education in cases where harm may occur. However, the Court was not explicit in advocating this control as a general principle.

The Tinker Test

In 1969, the U.S. Supreme Court heard the landmark case, Tinker v. Des Moines Independent School District (393 US 503), concerning the rights of students to exercise free speech in school. Three high-school and junior high-school students had planned to wear black armbands to school in protest of the country’s involvement in the Vietnam War. The principals of the schools in the district discovered the students’ plans in advance, and quickly adopted a policy that any student wearing an armband would be asked to remove it or face suspension. The students wore their armbands to school and were suspended for not removing them.

The opinion of the Court acknowledged the two countervailing forces present in the case – the right of schools to control conduct and the right of students to free speech. The court ruled that, in this case, the students were expressing “pure speech” since “the wearing of armbands in the circumstances of this case was entirely divorced from actually or potentially disruptive conduct by those participating in it.” (Id. at 505.) This case was contrasted with Cox v. Louisiana (379 US 536), in which two thousand black students protesting segregation were dispersed with tear gas. In that case, Justice Goldberg wrote:

“We emphatically reject the notion urged by appellant that the First and Fourteenth Amendments afford the same kind of freedom to those who would communicate ideas by conduct such as patrolling, marching, and picketing on streets and highways, as these amendments afford to those who communicate by pure speech. (Id. at 555.)

Students exercising pure speech, it seems, enjoy greater freedom than students who communicate with more disruptive forms of speech.

In the majority opinion of Tinker v. Des Moines Independent School District, Justice Fortas strongly asserted the rights of students in schools:

It can hardly be argued that either students or teachers shed their constitutional rights to freedom of speech or expression at the schoolhouse gate. (Id. at 506.)

Students may not be regarded as closed-circuit recipients of only that which the State chooses to communicate. (Id. at 510.)

However, he also acknowledged that “the Court has repeatedly emphasized the need for affirming the comprehensive authority of the States and of school officials, consistent with fundamental safeguards, to prescribe and control conduct in schools.” (Id. at 507.)

In making its judgment, the Court established a test criterion which would indicate whether the rights of the students or the schools were to take precedence. The opinion states that “the regulation [against the wearing of
armbands] would violate the constitutional rights of students, at least if it could not be justified by a showing that the students’ activities would materially and substantially disrupt the work and discipline of the school.” (Id. at 513, emphasis added.) If the speech of students was substantially disruptive, then the school had a right to restrict the speech. However, if the speech was not disruptive, then schools were prohibited from curtailing the speech of students. This test, known as the Tinker Test, became the basis by which many cases of free speech in schools have been judged. In the Tinker case, the judges ruled that since the students were exercising “pure speech,” which by definition is non-disruptive, the speech is protected by the First Amendment.

For schools that connect to the Internet, the Tinker case raises important issues concerning the right of the school to restrict student access to the network. Student E-mail messages and Usenet newsgroup postings appear to be in the category of “pure speech” because they cause little perceived disruption of school work. When a student sends a message, classes and other school activities are unaffected. However, in the not-so-distant future, classes may include on-line discussion among students in a virtual classroom. In this scenario, a student’s inappropriate use of the network is analogous to a student verbally expressing inappropriate comments in a classroom. This type of speech could be considered disruptive and would be subject to restriction by the school.

The Right to Receive Information

In the cases analyzed above, the right to free speech was viewed as the right to send information freely to others. However, the courts have broadened the definition of free speech to include a bi-directional flow of information; the Constitution guarantees the right not only to send information, but also to receive information (See Stanley v. Georgia, 394 US 557 (1969)).

In Sheck v. Baileyville School Committee, 530 F. Supp. 679 (1982), the U.S. District Court in the Ninth District of Maine heard a case pitting the rights of students to receive information against the right of a school to regulate the information introduced to students. The Baileyville school committee had removed from the school library Ronald Glasser’s 365 Days, a compilation of nonfiction Vietnam War accounts by American combat soldiers. The book contained coarse language and profane uses of “Jesus Christ” and “God,” which were deemed objectionable by the school.

The majority opinion said that the Tinker Test was not appropriate in this case because the banning of the book did not “directly restrict the readers’ right to initiate expression but rather their right to receive information and ideas, the indispensable reciprocal of any meaningful right of expression.” The Tinker Test applied only in cases of speech. However, in the case of receiving information, the Court opined:

The information and ideas in books placed in a school library by proper authority are protected speech and the first amendment right of students to receive that information and those ideas is entitled to constitutional protection. A book may not be banned from a public school library in disregard of the requirements of the fourteenth amendment.

Therefore the Court ruled for an interim injunctive relief from the ban.

The right of students to receive information has important implications for the Internet. As schools connect to the network, they access a broad web of information sources. Some of the information has educational value, but other information, including pornographic and violent materials, has little value for schools. With an established right to receive information, the issue becomes whether students can demand access to all information accessible from the school’s Internet connection.

So far, schools have taken measures to prevent students from reaching inappropriate content. In some instances, the school has used a technical solution that limits Internet access to a few selected newsgroups with perceived educational value. In other instances, the school has adopted a policy solution to prevent students from accessing inappropriate information. The school creates an Acceptable Usage Policy (AUP), a quasi-legal document signed by students and their parents, agreeing that they will not use the network for non-educational purposes. The texts of the AUPs vary from school to school, but generally they give the school the right to terminate a student’s network privileges if the student uses the Internet to access inappropriate information. By signing an AUP, the student relinquishes the right to receive certain information over the network.

Libraries, Textbooks and the Internet
Although the Courts affirmed the right to receive information, they further clarified this right as it applied to different information sources in schools. In Minarcini v. Strongsville City School Committee, 541 F.2d 577 (1976), the U.S. Court of Appeals for the Sixth Circuit drew a distinction between information received from textbooks and from libraries.

The high school in Strongsville, Ohio refused to approve Joseph Heller’s Catch 22 and Kurt Vonnegut’s God Bless You, Mr. Roswater as texts or library books, ordered Vonnegut’s Cat’s Cradle and Heller’s Catch 22 to be removed from the library, and issued resolutions which served to prohibit teacher and student discussion of these books in class or their use as supplemental reading.

The opinion of the case was divided into multiple sections. The first section, entitled “The Board’s Decision not to Approve or Purchase Certain Texts,” deals exclusively with the issue of textbooks. The Court ruled that “we find no federal constitutional violation in this Board’s exercise of curriculum and textbook control as empowered by the [State of] Ohio.” (Id. at 580.) The second section, entitled “The Removal of Certain Books from the School Library,” deals exclusively with the issue of the library. In this case, the Court finds that the school has less power in exercising control:

Neither the State of Ohio nor the Strongsville School Board was under any federal constitutional compulsion to provide a library for the Strongsville High School or to choose any particular books. Once having created such a privilege for the benefit of its students, however, neither body could place conditions on the use of the library which were related solely to the social or political tastes of the school board members. (Id. at 582.)

Therefore, the school can exercise great control, a priori, over the decision to attain a book for the school library. However, once the book is in the library, the school could not remove it without extenuating circumstances.

The law regarding use of the Internet in schools is dependent on whether the network is viewed as a textbook, library, or neither. The Internet is an abundant network of digital files, web pages, and Usenet newsgroups. Once the school connects to the network, it has established a link to each of these sources. The connection can be understood as having instantaneously created an enormous digital school library. As ruled in Minarcini, the school does not have a right to restrict access to information existing in a library. An analogy can be drawn from the school’s selection of books for its library to the selection of information for its digital library. By signing an AUP before receiving access to the Internet, the student has agreed that only certain types of files on the Internet are part of the school domain. Schools that do not use an AUP at the time of connecting to the network seem to place themselves in a precarious situation; once the digital library has been established, the school may not have a right to restrict students from the information it houses.

The conflict between banning a library book and free speech was further examined in the U.S. Supreme Court case Board of Education v. Pico, 457 US 853 (1982). The Island Trees Union Free School District in New York had ordered that certain books be removed from the school libraries. The majority decision in the case established from the outset that the case was limited in scope because it dealt only with library books and not textbooks. The distinction was made because library books “by their nature are optional rather than required reading.” (Id. at 862.) The opinion later elaborated why the distinction is important:

Petitioners might well defend their claim of absolute discretion in matters of curriculum by reliance upon their duty to inculcate community values. But we think that petitioners’ reliance upon that duty is misplaced where, as here, they attempt to extend their claim of absolute discretion beyond the compulsory environment of the classroom, in the school library and the regime of voluntary inquiry that there holds sway. (Id. at 869.)

Therefore, the school board does have a duty to “inculcate community values,” but that duty does not extend to non-compulsory domains including the school library.

The implications for the Internet depend on the extent to which it is a compulsory domain. On one hand, the schools that are connecting to the Internet are using the network for class work and exercises. On the other hand, the school is also making the network available to students to use at their own discretion for research or communication purposes. The law suggests that the students may have different rights based how they are using the network. It is conceivable that during school hours, use of the network will be restricted, but after hours it will be completely free.

In the case of the library, the majority opinion in Board of Education v. Pico asserted that the motivation of a ban determines its constitutional validity:
Our Constitution does not permit the official suppression of ideas. Thus whether petitioners’ removal of books from their school libraries denied respondents their First Amendment rights depends upon the motivation behind petitioners’ actions. If petitioners intended by their removal decision to deny respondents access to ideas with which petitioners disagreed, and if this intent was the decisive factor in the petitioners’ decision, then petitioners have exercised their discretion in violation of the Constitution. (Id. at 871.)

While it is clear that the school has some right to restrict information that is vulgar or obscene, it does not have a constitutional right to restrict information because of the ideas conveyed in it. This distinction is entirely appropriate in regulating access to the Internet. The language of AUPs has clearly indicated that schools intend to restrict student access to and prevent transmission of obscenity, violence and vulgarity on the Internet. However, schools would not be legally justified in using an AUP to restrict student access to ideas.

In Board of Education v. Pico, the court ruled that the school was in violation of the First Amendment in removing the books from the libraries. The decision was a narrow one, five to four, with two concurring opinions in addition to the dissent written by Chief Justice Burger. The dissenting opinion took issue with the majority’s decision that the ban was in violation of students’ First Amendment rights to receive information. J. Burger wrote that although Stanley v. Georgia, 394 US 557 (1969), establishes the right to receive information, it “does not carry with it the concomitant right to have those ideas affirmatively provided at a particular place by the government.” (Id. at 887.)

J. Burger argued that although the government provided the school with a library, it was not obliged to stock the library with controversial books. Similarly, those who invest resources in connecting schools to the National Information Infrastructure (NII) may not feel obligated to provide students with controversial information. Currently, the task is to lay wires and give schools physical telecommunications connections. However, once the classrooms are wired up, the issue will turn to the information schools will receive over the NII.

The Hazelwood Test

The Internet can be used for a variety of educational functions within the school. While schools have used the network primarily as an information source replacing or supplementing textbooks and libraries, the Internet can also be utilized as a communication tool. In fact, while the Internet was initially developed as a means to access information remotely, it has gained popular support mainly due to its communications capabilities. The school newspaper is an important means of student communication, both within the school and with the community. Schoolchildren are increasingly using the Internet to produce on-line school newspapers through web pages and file sharing applications.

Just as in the case of textbooks and libraries, students do not have full First Amendment rights in publishing school newspapers. Since students are using the Internet to publish school newspapers, decisions of the courts on the rights to free speech in newspapers have implications for rights and censorship of school Internet connections.

In 1989, the U.S. Supreme Court heard a case concerning the rights of school officials to censor the student-run newspaper. In Hazelwood School District v. Kuhlmeier, 484 US 260 (1988), a school principal had removed two pages of a school newspaper that included articles on students’ experiences with pregnancy and the impact of divorce on students. The principal objected to the pregnancy article because the pregnant students, although not named, might be identified from the text, and because he believed there were inappropriate references to sex and birth control. He objected to the divorce article because the student’s parents were not given an opportunity to respond to the article.

The majority opinion in the case established that in order to find a ruling, it must be determined whether the students participated in a public forum:

The public schools do not possess all of the attributes of streets, parks, and other traditional forums...Hence, school facilities may be deemed to be public forums only if school authorities have “by policy or by practice” opened those facilities “for indiscriminate use by the general public.” If the facilities have been reserved for other intended purposes, “communicative or otherwise,” then no public forum has been created, and school officials may impose reasonable restrictions on the speech of students, teachers, and other members of the school community. (Id. at 267.)

This statement of the Court provides the definition of the Hazelwood Test. In the case where there is no public forum in the school, the school may regulate student speech. However, if a public forum has been created, then regulation by school officials seems to be in violation of the First Amendment. The court ruled that in this case,
the school newspaper was not a public forum because it was part of the overall curriculum of the school. Therefore, the school was not in violation of the students’ rights by censoring articles.

The court also made a distinction between this case and Tinker v. Des Moines Independent Community School District. Tinker v. Des Moines Independent Community School District addressed whether the school had a right to restrict the speech of a student on school grounds. Hazelwood v. Kuhlmeier “concerns educators’ authority over school-sponsored publications, theatrical productions, and other expressive activities that students, parents, and members of the public might reasonably perceive to bear the imprimatur of the school.” A school newspaper, whether or not it physically includes the school masthead, seal, motto, or name, is viewed as a representative organ of the school. In contrast, students wearing armbands represent only themselves. The school enjoys a greater right to regulate than in Tinker v. Des Moines Independent Community School District because the students wearing armbands in Tinker v. Des Moines Independent Community School District were not speaking under official school capacity. Furthermore, the school in Tinker v. Des Moines Independent Community School District had enacted punishment (i.e. suspension) to the students for acts of speech it did not condone. In Hazelwood v. Kuhlmeier, the school exerted preventive measures, by refusing access to its resources (i.e. newspaper printing) before the inappropriate speech was communicated.

Since the cases are different, the Court decided that the standard articulated in Tinker (“materially and substantially disrupt the work and discipline of the school.”) need not also be the standard for Hazelwood v. Kuhlmeier. Instead, the Court ruled that the school would not be in violation of the First Amendment if the school “takes into account the emotional maturity of the intended audience in determining...[the appropriateness] of potentially sensitive topics,” (Id. at 271.) and if the control it exercises is “reasonably related to legitimate pedagogical concerns.” (Id. at 272.) This criterion -- reasonable relatedness to legitimate pedagogical concerns -- has become known as the Hazelwood Test and is used in similar cases to determine if First Amendment rights have been violated.

Two recent federal cases (Virgil v. School Board of Columbia City, 862 F.2d 1517 (1989) and Planned Parenthood of Southern Nevada Inc. v. Clark County School District, 941 F.2d 817 (1991)) have used the Hazelwood test in determining if the rights of students are violated by school regulations and control. In each case, the court found that the imprimatur of the school was present and the school was acting with legitimate pedagogical concern. With both conditions of the Hazelwood test fulfilled, the courts found that the school was not in violation of the students’ First Amendment rights.

Application of the Hazelwood test to the Internet in schools yields conflicting answers. On one hand, newsgroups and public email lists on the Internet are public forums; they are accessible to anyone with a computer, modem and connection from an Internet service provider. The local area network (LAN) within the school, if one exists, is not an open forum, because only those users with accounts on the system can be part of the network. However, once the school LAN is connected to the Internet, messages and files that sent over the Internet enter the public domain. Many schools have chosen not to connect to the Internet directly, but only to download information from the Internet onto the school server. In this case, the school is not fully connecting itself to the Internet public. However, for those schools with “full Internet connectivity” (e.g. WWW, telnet, ftp), the school network becomes part of a global public data network. The Hazelwood test strongly suggests that those schools may not restrict student speech over the Internet because the network is a public forum.

The second criterion of Hazelwood paints a different picture for Internet use. A school has a right to restrict speech if the speech carries with it the imprimatur of the school. Whenever any file is sent from the school over the Internet, be it an E-mail message, web page or ftp file, the data packets contain the Internet address from where the file originated. In fact, the address is recorded not only when students send information, but also when they retrieve information from the network. (All WWW and gopher servers and FTP sites log the addresses of all users who access information at that site.) In most cases, the Internet address is of the form name@school.edu, marking the imprimatur of the school in any information exchange. Therefore, application of the Hazelwood test suggests that the school may have a right to restrict the information sent or received through E-mail, ftp, gopher and the web.

Conclusion

The Internet and the NII will play an increasingly important role in K-12 education. Teachers, parents, school officials and students are clamoring to connect to the “information highway” as soon as possible. Much of the country’s energy and money expended so far has been directed at solving the technical, financial, regulatory and educational challenges in wiring up schools. As solutions are found to meet these challenges, the public will find
that new legal questions will arise as a result of the implementation of a national educational network. Students and schools will be at odds over whose rights are supreme in the digital environment. Students will claim that the First and Fourteenth Amendments guarantee them the right to unrestricted free speech over the network. School officials will counter that, as an agent of parents, the school has a duty to protect children from the glut of inappropriate information flowing over the Internet.

There has been virtually no case rulings on the rights of students on the Internet. However, rulings from analogous cases of free speech in schools may provide principles by which the law for computer networks can be extrapolated. Unobtrusive communication on the Internet seems to be similar to the “pure speech” given greater constitutional protection in schools. However, as the Internet becomes a widespread medium of communication within classes and among students and teachers, speech on the Internet will have the same potential to disrupt school work as does shouting in the classroom or picketing in the hallways.

Today, if a student refuses to sign an AUP, the school will not issue an account on the Internet. As the NII evolves, however, the school may have no more of a right to restrict access to the network than to the library. The students may become unwilling to waive their rights to free speech and will demand full access to the Internet. Their rights to free speech will be at odds with the rights of the schools to censor inappropriate information or speech. The law to be applied will depend on whether the network is viewed as a library, textbook or newspaper. With different rules in each of these cases, it is possible that the courts will base its rulings on how the network is used. However, it is likely that the network will be used simultaneously for a number of different functions. When that happens, the courts will be compelled to complement legal precedent with innovative decisions that address the multifaceted nature of the Internet.

References


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Presenting HyTime Documents with HTML

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Abstract: Due to the wide-spread use of the WWW, many institutions are using HTML to encode their documents for hypertext presentation. However, HTML is not always suitable for long-term document storage. Hypermedia/Time-based Structuring Language (HyTime) is designed for the long-term and presentation-independent storage of hypertext documents. Because of the close relationship both HTML and HyTime have with Standard Generalized Markup Language (SGML), HyTime-encoded documents can easily be translated into HTML. This paper discusses the issues involved in such translations.

Introduction

HTML has become widely used as a format for hypermedia documents. It specifies a model for text documents with hypertext links and non-text media objects. While HTML has served the needs of current hypertextual usage, it falls short of answering the anticipated demands of hypermedia environments. In particular, HTML enforces a single document that is closely tied to its presentation. As such, HTML is an inappropriate format for the long-term storage of hypertext documents that may be presented by means other than HTML browsers.

Standard Generalized Markup Language (SGML) [Goldfarb 91] and Hypermedia/Time-based Structuring Language (HyTime) [ISO 92] encode the presentation-independent structure of hypermedia documents. They also specific, using Document Type Definitions (DTDs), the general document structures of classes to which individual documents can conform. SGML defines a set of fundamental primitives for defining documents and document models. HyTime extends SGML by defining composites that represent hypermedia structure. HyTime constructs locate document objects, establish relations between objects, and schedule the placement of objects using measured coordinates. HTML is defined as a single SGML DTD. The fact that HTML and HyTime share a common foundation in SGML facilitates the conversion between them.

This paper describes three categories of conversion: hyperlinking, locating, and scheduling. Hyperlinking is establishing relationships between document portions. Locating is defining document portions so they can be referred to individually. Scheduling is defining numeric relationships between document portions. We first discuss the issues in converting HyTime documents into HTML for presentation. Background information on HyTime and SGML are provided. The HyTime and HTML constructs involved in conversion are described. The potential conversions between HyTime constructs and corresponding HTML constructs are discussed. Finally, related work is described and a summary provided.

Background

SGML

Standard Generalized Markup Language (SGML) is an international standard for defining the textual encoding of document structure and content. It delimits the text content into containers called elements. Elements can contain other elements, text, or both. Each element has a generic identifier (GI) that states the element's type name. SGML defines attributes that are associated with and describe elements. Each attribute has a name and a value. Two particularly useful attribute types are the unique identifier (ID) and the unique identifier reference (IDREF). An ID attribute gives its element a unique name within the document. An IDREF attribute has as its value the ID of some other element in the document, thus representing a reference to the element. The third primary construct of SGML is the entity. One of the most important uses of the entity is to enable the inclusion of external files in any format, even non-text, in a document element. Together these constructs provide the hierarchical structure of a document, descriptive information about portions of the document, and the inclusion in the document of external resources and information. A DTD defines a set of element types that can be used in conforming SGML documents. It also defines the set of attributes that can be used with each element type.
HyTime

Hypermedia/Time-based Structuring Language (HyTime) is an international standard for defining the SGML encoding of hypermedia document structure. HyTime defines a set of primitives, called architectural forms, that represent the hypermedia aspects of a document. These aspects include multi-directional and multiply anchored hyperlinking, descriptive, flexible, and powerful document object locating, and the scheduled placement of document objects along measured axes. HyTime extends SGML by defining how instances of these architectural forms are built from SGML constructs. An SGML element is recognized as an instance of a form if an HyTime architectural form attribute is assigned to it. Usually this attribute's name is "HyTime". Its value is the name of the form to which the element conforms. When an element is a form instance, particular HyTime attributes can be assigned to it. These attributes provide information about the hypermedia nature of that element. Elements conforming to forms are called HyTime elements. As an open document architecture, HyTime does not enforce a single document model. HyTime does not specify a single DTD but instead defines constructs that can exist in documents of different DTDs. While such DTDs define separate models, their documents can all share HyTime definitions that are uniformly recognized.

HyTime Hyperlinking Constructs

Some HyTime elements specify hyperlink structures. Such elements reference groups of document objects and describe a relation that exists between them. The contextual link (clink) architectural form establishes that a simple hyperlink exists between two document objects. One of these objects is the clink element itself. The other object is specified with an attribute named linkend. The independent link (ilink) architectural form provides a more complex definition for hyperlinks than the clink. An ilink element can, for example, link together more than two objects. It can also restrict the direction of traversal between objects. Role names can be defined for an ilink's link ends. When used in conjunction with certain location addressing constructs, an ilink can define a cascading sequence of hyperlinks that can be traversed one at a time or all at once.

HyTime Locating Constructs

Some HyTime elements specify location addresses. These associate an SGML ID not with a single element but potentially with more complexly defined document objects. When an IDREF is made to a location address element, the reference is not to the element with the ID but instead to the document object the element's address locates. The notation location (notloc) architectural form uses a string in a particular non-HyTime notation to address a document object. The name space location (nameloc) and name list specification (nmlist) architectural forms enable the location of objects in external SGML documents using their IDs or entity names. SGML by itself allows elements and entities in the same document to be referenced by their ID or entity name.

HyTime Scheduling Constructs

Some HyTime elements can define measured coordinate systems and the placement of document objects within those systems. A timeline for presentation could be such a coordinate system. HyTime could then specify particular document portions as occurring at specified times. Such a coordinate system could also map the areas of a display screen. Images could be specified as document objects that are displayed at particular locations on the screen. The event schedule (evsched) architectural form specifies a collection of objects with measured placements in one instance of a coordinate system. An event schedule could represent a single screen display or one possible timeline of a multimedia presentation. The event architectural form represents the placement if a single object in an event schedule. It assigns one set of coordinates to that object. The contents of the event element define the object being placed in the schedule. The extent specification (exspec) architectural form is used by an event element to define its coordinates.

HTML

HTML Hyperlinking Constructs

The interactive behavior of HTML documents is defined by HTML anchor (a) elements and their hypertext reference (href) attributes. The contents of such elements are considered "hotspots". Their selection by the user causes another document or document portion to be displayed. This relationship between a hotspot and the
display its selection creates is typical of hyperlinks. Such links in HTML are one-directional: selecting the hotspot brings up another document segment, but that segment does not necessarily act as a hotspot back to the original location. Also, each anchor can only link to one other document object.

HTML Locating Constructs

Although HTML uses SGML, it uses neither entities to reference external files nor SGML IDs to reference portions of the same document. There are attributes in HTML, however, that use HTML-specific schemes for such references.

These attributes can have their values in Uniform Resource Locator (URL) notation. This notation specifies the locations of document objects on the WWW. Such an attribute can also have as its value the pathname of a file relative to the current document's pathname on its file system. In either case, the located file is considered to be the object referenced. One such attribute is the source (src) attribute of the in-line image (img) element type. An img element specifies the occurrence of an in-line image within the display of a text document. The src attribute locates the file containing that image. The href attribute of the anchor element also performs such a reference. This attribute specifies what is presented when the element content is selected. A file located by this attribute can be of any medium type, as long as the system on which it is to be presented is configured to present that medium type.

In addition to the value possibilities described above, the href attribute can also reference a portion of an HTML document. Such a portion would be defined as the contents of an anchor element with its name attribute assigned. If the anchor tag specifies a name attribute, then other anchor href attributes can use that attribute's value to specify this anchor as a link end. An anchor's name would appear after a `#` character in an href attribute. The `#` and anchor name could appear by themselves to indicate the destination of this link is a named anchor in the same document. Putting a file pathname or URL specification before the `#` would locate the named anchor in the specified HTML document file.

HTML Scheduling Constructs

There are not many scheduling-related semantics in HTML. HTML defines no time-lines for presentation and no measured coordinate systems for screen displays. One HTML construct that suggests scheduling semantics is the image map. An image map is an img element that is defined as a hotspot (that is, as the content of an anchor element with its href attribute assigned) and has its ismapattribute assigned. Different portions of an image map can be clicked on to access different objects. The URL accessed by clicking on an image map is the href attribute value followed by a `?` character and two numbers giving the coordinates of the image where the mouse click occurred. The server specified in the URL can then process the address with the coordinate suffix to determine the appropriate document object to return.

Converting the Constructs

It is impractical to devise a scheme for converting all SGML or HyTime documents to HTML. The DTD of a document will typically define a model with components that have semantics particular to that document set. Most of the translation of such components to HTML code needs to be done for each document model individually. However, there are some HyTime constructs with semantics that are general enough to suggest a common HTML interpretation across all document models. Some of these constructs were introduced earlier in this paper. In this section, we discuss how these HyTime constructs could be interpreted into HTML.

Converting Hyperlinking Constructs

Although HyTime-defined hyperlinks are not strictly navigational in nature, navigational relationships are frequently encoded as hyperlinks. Given this association between hyperlinks and navigation, we discuss converting HyTime hyperlinks to HTML-defined hotspots. An href anchor defines only that one document object, when selected, leads to the display of one other. Defining traversability in the other direction would require an additional anchor element, or at least an additional href attribute. Each document object can be the start of only one link. HyTime, on the other hand, allows for the defining of very complex hyperlink structures. HyTime links can be bi-directional and involve more than two anchors. Further, allowable directions of traversal through a link can be restricted. Since HyTime hyperlinks are complex than HTML anchors, an individual HyTime link may need conversion to a composite of HTML anchors. Part of converting HyTime hyperlinks is
the conversion of the ID REF attributes defining the link ends, as discussed below in the section titled "Converting Locating Constructs".

A clink defines two anchors for a link. One anchor is the clink element itself and its contents. The other is specified by an IDREF attribute named linkend. A clink element could be represented in an HTML document by an anchor element with its href attribute assigned to locate the object the HyTime linkend attribute located. This anchor element would have most of the hyperlinking semantics of its source clink. However, since clinks can potentially be bi-directional, it may be appropriate to name the HTML anchor and put a href anchor around the located object reference back to the link's starting point. Below is an example of some HyTime clink code and a possible HTML conversion [Fig. 1].

An ilink element can define a hyperlink with more than two link ends. Since an HTML anchor can have only two link ends, it would take more than one HTML anchor element to present such an ilink. Such a conversion could consist of defining for each HyTime link end a collection of HTML anchors. Each anchor for a link end would access one of the other HyTime link ends. As such, each traversal allowed by the HyTime code from one linkend to another would be encoded as a distinct HTML anchor. Each of these HTML anchors would be displayed as a particular string or piece of text. This text is the content the each anchor. If the source ilink has anchor roles defined for it by HyTime, each resulting HTML anchor could contain the text making up this anchor role. As such, the user would see highlighted as hotspots the names of the various roles the anchors in the link has. The user can then select the appropriate role name.

A HyTime ilink element can have traversal direction restrictions placed on its anchors. Such restrictions could be reflected in the HTML anchors that are generated for an ilink. As described in the previous section, a separate HTML anchor can be defined for each possible traversal between a pair of link ends. Any such traversal that is not allowed due to a traversal direction restriction would not have its corresponding HTML anchor generated. As such, that traversal would not be enabled by HTML processing.

Converting Locating Constructs

Since HTML does not use any IDs or IDREFs, any use of unique identifier referencing in a HyTime document needs to either be eliminated or converted to an HTML-defined reference. This is true even if no HyTime location address elements are used as part of the reference. If the original reference is semantically appropriate for representation as an HTML referencing attribute, then such a conversion can take place. Such HTML attributes include the src attribute of the img element and the href attribute of the anchor element. As such, references to image files to display or to link ends of hyperlinks may be appropriate for this translation.

The converting of an SGML/HyTime reference consists of two parts. First, the start of the reference must be converted. This would typically consist of transforming an IDREF attribute into an HTML referencing attribute such as href or src. The value of the attribute would also have to be changed from the unique identifier to an HTML equivalent. This equivalent could be either a URL, a filename, or, in the case of href attributes, a named anchor. The second part of converting an SGML/HyTime reference is encoding the end of the reference. The reference destination must be represented so that it can be specified with HTML referencing attribute. If the destination is a file, then a URL string or file system pathname can reference it and no changes are necessary. If the destination is a portion of a file, then an HTML equivalent of that portion must be encoded so that it is or is contained in an HTML named anchor. As a named anchor, it can be referenced by the href attribute.

If a HyTime linkend attribute specifies an element as an anchor by referring directly to its ID, then its HTML translation could involve the creation of a named anchor. The semantics of the hyperlink would be encoded in HTML using the techniques for converting hyperlinking constructs described earlier. The destination of the reference would be encoded so that it was contained in a named anchor, perhaps given the same name as the original ID (assuming it was not already used as a name in that document). The href attribute for that link end would then reference this named anchor. As such, its value would be the name itself preceded by a "#". An example of the conversion of an IDREF to a named anchor is provided above [Fig. 1].

The World Wide Web has made the use of URL notation wide-spread. The use of URL notation in HyTime and SGML documents in general has been proposed [Kimber 93]. This approach involves using SGML code to define a notation named "URL", and then defining a HyTime notloc element type as containing a string in that notation. As such, a HyTime engine would recognize IDREFs to these notloc elements as references to the files
located by the URL strings they contain. IDREF attributes to such notloc elements in HyTime documents could be converted to an HTML attribute whose value is the notloc's URL contents.

Converting Scheduling Constructs

In earlier work, we have created a HyTime-defined document set for use with a kiosk-style multimedia presentation system [Buford et al. 94]. This document set and its application is called Hypermedia Presentation (HMP). Each HMP display has areas that are hotspots. Clicking on one hotspot causes another screen display to appear. These screen displays and their navigational nature are defined with HyTime scheduling and hyperlinking constructs. Screen displays are represented as an event schedules. Hotspots are defined as events containing clinks. This specifies that the areas in the schedule represented by these events are, in some sense, "hot". Each clink specifies as its other anchor the screen display event schedule to be shown next.

We have extended HMP so that these screen displays are shown on the WWW in HTML documents as image maps [DMSL 95]. As with the original application, clicking on a portion of the image that is a hotspot causes a particular new image to appear. The image is included in an HTML document as an in-line image. The fact that the image has hotspots is represented by its occurrence in an href anchor element. The ismap attribute indicates that selecting different portions of the image accesses different document objects. The coordinates of a selection are returned to the HMP http server for processing. The server then determines what hotspot event the selection occurs in and then returns the image map for the display that selection links to.

Related Work

At the Second World Wide Web Conference, Eric Freese discussed the presentation of SGML documents in general with HTML [Freese 94]. In previous work we described some possibilities for encoding HTML documents using HyTime [Rutledge et al. 95]. Other possibilities for such an encoding have been described as well [DeRose & Durand 94].

Summary

HTML is widely used for the presentation of hypertext documents but is not an appropriate format for the long-term storage of documents presented in a variety of circumstances. HyTime, with SGML, is better suited as such a format because it enables the defining of documents in terms of their presentation-independent structure. HyTime documents can be presented by converting them to HTML for processing by HTML browsers. This conversion is facilitated by both HTML and HyTime being defined using SGML. This paper approaches its consideration of the translation from HyTime to HTML by examining semantic overlaps between constructs of the two languages. HyTime hyperlinking constructs can be converted to patterns of HTML anchor elements with href attributes. HyTime location addressing constructs used in conjunction with hyperlinks can be translated into HTML anchor elements with name attributes. Finally, scheduling constructs used in conjunction with hyperlinks can be translated into HTML img elements with the ismap attribute set.

References


Abstract: IPERLER [1] is an integrated system that combines a World Wide Web Browser, a 3D Viewer and a synchronous Collaborative tool. The system aims to support the navigation between these "working areas" in order to enhance the potential interactivity of the World Wide Web (WWW) environment. With the IPERLER system, we intend to improve remote access to specific knowledge for distance learning, continuing education and training by combining the network technology, the powerful of visualization methods with the hypermedia material. The system is based on the interconnection of the 3D objects display, the WWW hyperdocument and the synchronous collaborative tool. The innovative side of IPERLER is the setting of hyperlinks within the 3D object associated to the description of visual attributes. The system is currently being used at CRS4 by students from the University of Cagliari for experimentation. We are planning to make it available over the network in a near future for a large scale utilization.

1 Introduction

At the beginning, Internet (and WWW itself) had the goal to help scientists exchange data. Presently, such a support allows them to carry out comparisons and interpretation from interactive, annotated 3D objects and visualizations that explain their ideas in a way that is unachievable in 2D.

Several research activities carried out at CRS4 in medical imaging, geosciences or biomedicine, for instance, show new learning concepts for established curricula. Their distribution with accurate representation cannot be based on lecture lessons but need different representation according to the nature of topic.

The use of interactive multimedia systems through the WWW will improve the quality and speed of the information treatment. Several interesting applications have been developed using the powerful exploration strategies allowed by the WWW communication protocol. The drawback is that the treatment and the assimilation of information require more than a sample exploration or the consultation of multimedia hyperdocuments.

Interactive visualization leads learners to be active in looking for and selecting data. But as well as for text based presentation, even new support should push the users to interact and keep the control on any solution they decide to select while dealing with the construction of knowledge. The techniques now available in the field (interactive manipulation of 3D objects, animations etc) give interesting solutions for both problem-solving and high order knowledge.

It is thus critical to put more effort into the process of visualize the knowledge and its structure in order to go beyond the explorative way WWW is used now for knowledge treatment and interpretation of new concepts. Learning is related to active problem solving and involves the user participation for the compilation of new contents. In this perspective, the learning material has to be a lesson oriented hypermedia highly interactive optimizing the perception of relationships between concepts.

The visual representation technique will increase the interactive potential of the WWW as soon as visual elements become manageable by users in an instructional environment to control navigation path and the access attached explanations.

Recent developments like the proposed VRML (Virtual Reality Modeling Language) standard allow to combine 3D interactive worlds where the user can navigate in with a WWW browser. This provides an appealing and revealing interface for exploration, inspection and, most importantly, selection of elements of interest while getting involvement.

Although the system presents different areas of work, we have chosen for this article to focus on one aspect in particular, that of the interconnection between 3D visualization and hyperdocuments.

2 The IPERLER Proposal
2.1 Areas

The system proposes to the students to use different areas which correspond to the:

- Manipulation of a 3D learning object. The learning object is represented in 3 dimensions, the student can explore as s/he wishes the features of the object, manipulating and rotating it.
- The descriptive information contained in the hyperdocument. Both visual and textual representations are available.
- The collaborative part of study. In this area students can open a synchronous communication session and exchange information with peers and/or lecturers.

The areas are interconnected in order to enable the user to go back and forth as easily as having to perform nothing more than a simple "point and click" operation. The structure is schematically represented in Fig.1.

![Figure 1: The IPERLER architecture](image)

2.2 The Interconnection among the Areas

The didactical material can be accessed from both the 3D viewer and the WWW browser. By such interconnected information, the student can follow internal links as well as transversal links. The manipulation of the model allows a personal inspection of the visual elements and a free consultation of their descriptive attributes.

The didactical network of the learning topic is built over the entire material. The interconnection between the 3D viewer and the hyperdocument is the technical point that allows a large distribution of information. The information is organized in order to markup relationships between physical characteristics and attributes. Such a strategy should enhance the effective treatment and the encoding phase of data.

2.3 How to Visualize

To quote Einstein, we can here recall the scientist's idea about the importance of visualization:

"The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought..."

It seems that the bulk of studies and work for visual representation carried out by several among the greatest "minds"
(e.g., Galileo's conversion of empirical observation in a deeply visual chain of visual reasoning to explain what the "eye of mind envisions", [Tuft 90]) has not been considered enough important for pedagogical design: our entire educational system continues to be based on the study of words and numbers.

We use images as a complementary aid for knowledge understanding but we do not reach the construction of visual representation that presents parts in separate views without missing the whole.

Despite an important evolution of graphical techniques, it is still difficult to help someone survey the multi-variables of an image. Too often, the distraction effects of pictures [Rieber 94][Samuels 70] as well as its ubiquitous use have been underlined in the author's studies.

It cannot be well understood when it is shown via the consecutive method (a number of snaps as parts of the whole). We try to identify some solutions that are presently based on the properties of interactivity for a hyperobject.

2.4 Introducing Hyperobjects

We define Hyperobject a Digital Direct Method (DDM) for visual representation: a tool coupling the Direct Method paradigm and the Narrative Method paradigm in a digital system based on a networked environment [Salis, Scateni, Leone & Vandamme 95].

By Direct Method, we mean the possibility to construct and tear apart a 3D model presenting what we are observing; by Narrative Method, instead, we mean the possibility to symbolically describe objects and their relations [Tufte 90].

Because of its observable macrostructure and microstructure, the hyperobject allows the user to envision different dimensions and variable aspects of the object as s/he is used to do in everyday experiences. By applying the VRML description format, semantic links can be activated from any part of the 3D object to the HTML document. The user interact with a dynamic object (get different views of the object) as well as with its single parts (activate attached connections to other dynamic object or HTML document). The idea of hyperobject has been highly influenced by the hypertext principles like the structure, the semantic connection and the quality of the navigation facilities.

3 Theorical Framework

3.1 The Cognitivist Approach

Main principles of the cognitive and the referential processing we refer to : The pedagogical design of tools has been carried out upon principles related to the activation of mental phases for the construction of knowledge. According to this point, we are in a larger manner interested in the cognitivist psychology's point of view and we focus on the external conditions as studied by Gagné [Gagné 84].

Gagné has associated an external condition (intervention) for each of the learning phases (according to the nature of the knowledge of interest) which can support the cognitive processing. One of the fundamental activities of cognitive processing is the integration of new knowledge to the cognitive structures of the learner.

Mayer [Mayer 79b] stresses the importance of an external function which is viewed as a pedagogical strategy that favors the integration phase. But, the integration of new knowledge or part of it can happen only when a mental representation has previously occurred. The mental representation is here discussed in relationship to the dual coding model for memory and cognition (DCC) as Paivio theorized. [Paivio 86 in Rieber 94]. We consider that such a theory belongs to the larger visual cognition branch itself attached to the cognitive psychology domain.

3.2 Visual Cognition: The DCC contribution to the ISD process

The representational processing as considered by Paivio brings about addictive effects when the verbal and non-verbal coding systems are requested. According to Kobayashi [Kobayashi 86 in Rieber 94]), addictive effects can explain what happens with the referential connections mechanism. The referential connections occur from one coding system to the other and makes impossible not only the double coding of information (verbal/non-verbal) but also the retrieval operation from both these systems.

We stress on this particular point because of the importance of the main features coding activity within the short term memory. The coding operation of main features is well known as being a conditional step for the assimilation of
information as well as for its retrieval and transfer. 
Levie defined the perception task as "the process of selectivity attending to and scanning a given stimulus, interpreting significant details or cues, and, finally, perceiving some general meaning" [Levie 87].

We are led to think that 3D visualization and manipulation of features while interconnected with verbal hyper nodes should enhance the coding activity. According to Rieber, information encoded in both verbal and visual forms with strong and flexible links between the codes should enhance retention, retrieval and transfer. We want to add here that the VRML to/from HTML interconnection mechanism should aid learners to perceive features thanks to the high control and flexibility users maintain while they manipulate an object and activate related hyper nodes.

Therefore, we apply what Paivio calls referential stimuli, which is the interrelation between verbal and non-verbal signals. We utilize the interconnection technique between a hyperdocument (multimedia + hypertext) and a 3D environment within the theoretical framework as presented above and keeping in mind the main principles that derive from this framework (e.g. presentation principle and cognitive principles of the instructional graphic, the mental processing principles applied to the pedagogical design of material). Such a framework has allowed us to carry out the material design. It has been set up from ISD techniques for the analysis and the development phases.

The main factors we take into account while we determined the nature of external conditions are as follows:

- The bidirectional access of didactical material happens from both 3D viewer and www browser. By such interconnected information, the student can follow internal links as well as transversal links.
- The manipulation of the model allows a personal exploration of the topic as well as the internal links of the hyperdocument. The user is managing some actions. S/he is active in order to select information.
- The 3D object, considered as a visual stimulus, can support the attention phase when it is shown first as a global view of the learning topic. This helps the student to develop expectations on the specific domain he is going to deal with. The opportunity to handle the object becomes important to support the student's attention, and the selection of main features (we define these conditions according to the goal's analysis).
- For all levels of representation, the main characteristics are emphasized via activable connections. We assume that attention is maintained constantly, thanks to the high level of participation the system requires from the student (see Fig.2: the IPERLER strategies).

In synthesis, the semantic network of the learning topic is built over the entire didactical material. The interconnection between the 3D viewer and the hyperdocument is the technical point that consents a large distribution of information. The information is organized in order to underline relationships between physical characteristics and attributes. Therefore, the bidirectional access of information should support the referential processing as described above.

![Mental Events Activation Diagram](image)

**Figure 2: The IPERLER strategies**

4 The Current Application: Studying Anatomy
The IPERLER system is currently being applied for pre-testing phase at the department of Anatomy at the University of Cagliari. The research interests of some lecturers of the department led us to select as learning topic the spinal cord (a sub topic of the central and peripheral nervous system). A student's group is using the system locally, they can access the didactical material that includes the hyperdocument and the 3D object.

4.1 Specific Needs

The complexity of the spatial elements the student has to remember and the associative cognitive task s/he has to process in order to link labels and characteristics to the anatomical elements are cognitive activities the 3D representation can support. Our goal is first to enhance this capability adding not only text to the 3D model but also hyperlinks, pointing to text documents accessible by the Web browser or to other 3D objects accessible within the 3D Viewer itself. By using a 3D viewer, the student can observe and manipulate different 3D elements of the spinal cord. The 3D model is thus a hyperobject.

4.2 Description

The hyperdocument presents internal links that have been established by the anatomy experts. A set of didactical aids are available in every page (structure, definitions, keywords, summary, case studies, glossary and help). The communication area is also accessible from the hyperdocument (asynchronous and synchronous communication). From inside the hyperdocument the students can reach external web sites.

The WWW browser we currently use is Netscape, we use Webspace as 3D viewer developed by Silicon Graphic Inc., and NCSA Collage as synchronous collaborative tool.

4.3 Exploring 3D Hyperobjects

Using the 3D viewer the user can freely observe the elements of the spinal cord (dorsal, ventral and lateral views). The users can handle the anatomical object with the trackball, point on its particular components, zoom and move it on the screen.

We presently implement 3 levels of representation of the model: The spine as a whole, each single section and each single vertebra.

All the elements in the model are links to other hyperobjects, either VRML files (3D) or HTML files (documents).

4.4 Visual Treatment of Information

In order to develop the idea of the visual representation, Brien [Brien 91] illustrates the example of a surgeon who is just about to operate and hypothesizes the lack of a global representation of the anatomical part by the surgeon...

What is going to happen when the clinician decodes the description of the symptoms?

The clinician refers to his/her knowledge scheme most appropriate to the particular situation, which is stored in his/her long term memory. A visual representation of the anatomical part is mentally generated in order to place the hints offered by the patient. Each of the elements obtained corresponds to specific attribute to be later related one to another, in order to establish a diagnosis [Coltorti 93]. The connection between the spatial position and functionality of an anatomical element is thus established, following the visual representation of the object in question. This representation is not stable if we consider that the injured point might not correspond to the actual regions of the symptoms.

The fact that the anatomical elements may be represented (not manipulated) could have an effect on the construction of the mental image but tends to lead to a "passive learning process" of the concepts. This favors a mechanical reproduction of knowledge more than its build-up from prior acquisition.

With this approach the comprehension of important patterns is compromised, since they are not discovered, but, at most, retrieved from an assortment of information. If the control of the manipulation of the 3D model is kept by the student, the actions of retrieving, selecting and organizing the information are more willingly undertaken and processed, thus stimulating the metalearning [2]

4.5 Interactive 3D Visualization and Multi Perspectives
The representation of the interactive 3D spinal cord is a means by which the student builds different mental images. These images constitute a very important type of memorial encoding. The main difference between the static picture and the interactive one resides in personal ways of perceiving sub-elements of the object from different perspectives. A static picture shows certain specific features one may select during the perceiving process. The effects of Specific Retrievable Images [Gagné 84] (SRI) on the recall of prerequisite intellectual skills (from mental structure) have been well dealt with by many authors (see, e.g [Di Vesta & Rieber 87]).

The memorial encoding and storage of pictures includes specific features related to the context of learning. Nevertheless, when the same learning object must be studied under different conditions the transfer of the SRI may be unsuccessful because of the lack of effective perception of the properties of the anatomical section. The power of an interactive 3D object may be discussed on one hand, from the control to view different areas, and on the other hand, from navigation technique the user can utilize to reach a multimedia database. The user has access to supplementary and/or basic information (sound, text, 2D image, animation) on the topic by activating a connection between the interactive 3D viewer and the WWW browser. Each section of the 3D model has its particular properties described by the experts.

It should also be noted that such a "3D visualization-hyperlinks combination" has many other valuable characteristics to support the studying activity. In this combination, visual stimulation as a response to the manipulation request by the user is highly effective in controlling attention and directing selective perception. The effects of this combination enable the student to use the virtual model as an encoding device for study processing and as a source of cues for the retrieval of concept representation.

5 Future Extensions and Conclusions

After the pre-tests period, the small group of students reported that the manipulation of the 3D object is a powerful method for the memorization of features and the interconnection between visual and verbal information enhances the association of physical characteristics with their functionality. Nevertheless, we consider that loosening control on the 3D model while navigating in the hyperdocument is a weak point in the system. Unfortunately, the present protocol and browsers used do not allow for a simultaneous update of the two worlds. In the future, using emerging technologies such as the Java language for object-oriented design, we should have the possibilities of integrating the update mechanism and also the textual information in the 3D scenes.

Footnotes
[1] IPERmedia & Lavagna Elettronica in Rete (Hypermedia & Electronic Blackboard on Network).

References

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New Tools of the Trade: Using Multimedia in the History Classroom

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Abstract: History teachers have a new set of digital tools available for the "general diffusion of knowledge" in the classroom. These include (1) the portable computer, (2) multimedia tools, (3) presentation software, (4) CD-ROM, (5) e-mail, and (6) the World Wide Web. Statistics show a rapid increase in student computer use at the University of San Diego. However, many faculty still use the computer only for individual word and number processing. The new tools of Quicktake, Photoshop, Premier, Director, CD-ROM, and HTML are just starting to revolutionize the presentation of history in the classroom.

Remember how it used to be? Writing with chalk on the blackboard to spell "Massachusetts" for that boring history class; holding up an old issue of National Geographic to show where Africa was located; writing your lecture notes on a pad of yellow legal paper; spilling coffee late at night on that pile of term papers scribbled full of illegible red ink, hanging a clock on a wall to keep track of time during a test -- what wonderful memories!

Well, times have changed and the classroom has changed. A whole new group of tools has been placed in the hands of teachers to build that grand edifice we call knowledge. Like all new tools, they can be ignored and abused, or we can learn how to make them work better than the old tools. At the University of San Diego, I have made an effort over the last two years to learn these tools. [Schoenherr, 1996] I am convinced they can be effective instruments to achieve what Thomas Jefferson sought 200 years ago, a "general diffusion of knowledge" [Malone, 1981].

The first tool is the computer. Instead of keeping my Macintosh 6100 on my desk in the office, I have moved it to a portable cart and routinely wheel it into the classroom (which is fortunately nearby; for more distant locations, I borrow one of the school's Powerbook laptops). Jefferson used a laptop portable desk to write the Declaration of Independence, and a polygraph copying device to extend his ability to write [Bedini, 1984]. We can do the same today with the computer. One plug goes into the ethernet jack; another plug goes into the RGB video input, and in less than a minute my class is looking at my computer images projected through the same ceiling-mounted video projector that shows videotapes. But there is a crucial difference: I do not turn my class over to the videotape and become a passive spectator. Instead, the computer is my tool to interact with the class in a far more dynamic way than with a videotape. It combines into one box what used to be the standard tools of the blackboard, overhead, slide projector, mapstand, textbook, and even that old yardstick used to point at things on the screen. I have found a very useful little package called the Electronic Marker ($30 in the mail-order catalogs) that lets you use the mouse to highlight, point, check-off, underline, or draw lines on top of any other program running. No more yardstick. Instead, I become John Madden drawing lines on the instant football replay. Using the topographic maps created by Andrew Birrell, I am able to demonstrate a map of key geographic features important in the early American period of discovery and colonization. Using histori cal maps from the University of Texas Perry-Castenada collection, I am able to show the changing boundaries of the U.S. as it grew from 13 mostly seaboard colonies to a continental empire.

With the computer of today comes a second group of multimedia tools. These add sound and image to the traditional text handling potential of the computer. The PowerPC Maccs have built-in 16-bit sound capability, allowing you to play audio-CD quality digital sound directly from RAM or disk. One of my first multimedia projects was to play a song by U2 from their Joshua Tree CD called "Where the Streets Have No Name" with pictures from U.S. History and from the Joshua Tree National Park to illustrate the lyrics.[Schoenherr, 1994] To play Franklin Roosevelt's Fireside Chat of Feb. 23, 1942, I used Adobe Premier to capture the audio track from some old open reel tape recordings of his speeches that I made at the Laguna Niguel National Archives from government archival recordings. I used Premier's razor blade tool to cut out the section I wanted to play in class, saved it as a Quicktime movie, and played it from my hard disk through the classroom amp and speakers. The Apple Quicktake 150 digital camera lets me take 16 high-resolution full-screen 24-bit color photos and upload
them to the computer without the cost and delay of film developing. It has proven useful in photographing historic sites and buildings in southern California for use in my classes on the Mission Era, the Mexican War, the characteristics of Victorian architecture, and the impact of the opening of the Panama Canal in 1915. The Quicke

take has its limitations: slow shutter speed, non-threaded fixed-aperture lens, frequent artifacts in the image, only average sharpness and clarity. For those occasions when quality is more important than speed and convenience, I use a standard 35mm camera and film to make slides and negatives. Until this summer, I sent this film to Kodak to be transferred to PhotoCD. The images came back digitized in 5 resolutions on a CD-size disc. An example of one of these PhotoCD images digitized from a 35mm Kodachrome slide at the normal resolution of 72 dpi for a 640x480 computer screen is sunrise in Joshua Tree National Park. I copied these images from the PhotoCD to a Bernoulli removable hard disk, edited each with Photoshop and saved them as jpeg files. But this method was expensive, averaging $0.80 per image, and slow, with a 7-10 day turnaround. Given the fact that I had been making an average of 2000 images per year for use in 280 class lectures that I give each year, this was too expensive. So last summer I used some grant funds to purchase a Polaroid SprintScan slide scanner. Now I can digitize 35mm slides or negative strips at the rate of 90 seconds per image and get a higher resolution than with the Quicke take camera. For quality, the Polaroid is best, as can be seen in the image of the historic Machado-Stuart adobe in San Diego that I scanned from a 35mm Ektachrome slide. For speed and convenience, the Quicke take is more useful, as can be seen in color snapshots of students.

The software for these classroom presentations is a third important tool. Most consumers today never use anything more on their computer than the word processor or the spreadsheet (and of course the games). It was VisiCalc and WordStar that launched the personal computer revolution in 1979 [Polson 1996]. I have observed that many faculty with computers in their offices today use none of the software that is installed in the computer labs on campus. Yet it is software such as Photoshop and Infini-D that students learn when they take graphic arts classes. The student newspaper this year began to use Pagemaker for pre-press layout. A growing number of classes in the sciences and the business college require a working knowledge of the GIS software packages ArcView and ArcInfo. The PC software of today is powerful yet rarely used in the classroom. When I teach the American Civil War, I project outline notes of the Battle of Fredericksburg that I typed into Macromedia Director. I am able to talk and lecture and answer questions as the computer screen moves through the outline, just as a salesman would give his pitch with Microsoft Powerpoint or Adobe Persuasion. I can add additional "cast members" to my computer "score" in Director, such as maps, photos, music, and even Quicke time movies. Director is a nonlinear program that makes it a favorite authoring platform for CD-ROMs. By clicking on a variety of screen buttons, you can jump to a map or photo during the presentation of your outline notes, talk about the images, then click back to the notes. With at least a rudimentary knowledge of these programs, I can help students work on their own multimedia projects. I have been using Photoshop to scan pictures into a database of images that students can use. Each image is indexed with its http address into Filemaker Pro, the same software that I use to keep a record of class grades. I have found that practice makes perfect. Unless I sit down and use the software myself, I cannot help students learn how to use it.

A fourth tool is CD-ROM. These little discs of gold-coated plastic can hold 650 megabytes of data or 74 minutes of music, and are a true gold mine for the history teacher [Herther 1995]. The textbook from McGraw Hill that I use in my introductory American History class is also included in a CD-ROM Encyclopedia of American History published by Comptons [Brinkley 1995]. My students have the option of buying either the hardcopy or computer version, and for the same money, they get a great deal more information on the CD-ROM than in the book. I can put the disc in my Mac 6100, press the command-return keys to switch on the DOS card to run the Windows version of the disc, and project documents, maps, songs, and movies related to the topic we happen to be studying at the time. On my home page I keep a list of recommended titles for purchase by students through the university bookstore or through catalog dealers such as Educorp [Schoenherr 1995]. CD-ROMs can be made as well as played. I use a Phillips CD-ROM recorder to make my own discs for backup and for presentations. Like the tape recorder and the VCR, the recordable CD-ROM is another extension of our multiple senses. I agree with Marshall McLuhan that it is a "make-happen" medium more than a "make-aware" medium, even at a slow double-speed 150 millisecond transfer rate [McLuhan 1964]. But its random-access character and enormous storage capability give the teacher great flexibility in arranging a class presentation. The CD-ROM on the history of Old Town San Diego that I am producing with Dr. Iris Engstrand will hold books, articles, photos, maps, and 3D models of the evolution of the town over 7 decades from 1800 to 1870 [Schoenherr and Engstrand 1995].

A fifth tool is e-mail. I require all students to open an account on the university SPARC computer known as PWA with their own username and password. This account is free and available to all registered full-time students. This gives them the ability to send and receive e-mail, read newsgroups and discussion lists, connect to the Internet with gopher or ftp or WWW browser, and publish to their own Web pages. Statistics still show that
The sixth tool is the World Wide Web. Although it is fast-growing as a medium of entertainment and commerce on the Internet, I have used it to replace that dreaded pile of term papers. Students are given the opportunity during the semester to write a traditional paper or to write HTML pages. They can use their own computers or use one of the several Mac or Windows or UNIX computer labs available on campus. The brand of platform no longer matters. One great advantage of the Web is that it has become a uniform standard world-wide. Learning to write HTML tags is much easier than learning COBOL or C++. And it goes more quickly when students are shown how to do it rather than assigned a book to read about it. I bring the computer into the class room and spend one class showing them how to write a simple page. I then schedule sessions outside class in the computer lab to guide them through the creation of a Web page step by step. I use the several excellent tutorials online from NCSA [NCSA 1996] and USD's Department of Academic Computing [Stratton 1996]. I also wrote a short tutorial for my classes (and accessible from my home page) tailored to USD's network arrangement. Again, it is important to show how it is done rather than just read or talk about it. Concepts such as "hypertext" and "relative links" are best learned watching them get made on a computer screen and seeing the result immediately with the Netscape browser. In the past year, I have witnessed freshmen with little computer knowledge learn in a few days to write basic Web pages and improve them over a few weeks with pictures, links, and even designer graphics (e.g., Davina Hoyt's Tuskegee Airmen page before and after). They are excited and motivated because the process is creative as well as intellectual. They are making something rather than only writing something. This holds true for teachers as well as students. Linda Swanson has compiled a list of many different uses of the Web made by teachers and students at all grade levels in several different countries [Swanson 1996]. I believe every academic department in colleges should have a department page with information useful to students taking classes in that department. They can find information about professors, classes, research projects, social activities. At USD we even put on the History home page pictures of the Phi Alpha Theta meetings, lectures, and softball games [USD History Department 1996]. I have learned to write HTML to create pages for my classes and lectures on a daily basis, and to use Netscape as a presentation mechanism in the classroom. I can type a set of lecture notes in Microsoft Word, save them as a text file, drag and drop this file onto HTML Markup 2.0 from Scott Kleper to automatically turn it into a Web page, edit the page with a very simple HTML editor from Stan Stanier in England called High Tea (available from the MIT Info-Mac archive), add links to pictures and sounds, and run the page during the class with a portable computer. An example of these notes-turned-web-pages can be found in the World War II Timeline. This Timeline has been evolving since it was started in the summer of 1995, with new pictures and documents and timeline pages continually being added and modified. Students each semester have added pages of their own. One great advantage of the Web is its ability to change. While this can also be a source of confusion, I find it to be an inspiration to make things always a little bit better.

Finally, I want to end on the note that computers can do simple things in the classroom as well as big ones. When I give an exam, I run a little Mac shareware program written by Victor Franco called O'Clock 1.1.0, available from the Info-Mac archives. It shows a big round clock dial on the screen, easily visible to the class and a reminder of the exam's time limit. I don't have to write the time on the board, or answer constant requests for the time. I let the computer do it for me. By the way, O'Clock has been running in the background and I notice that my time is up.
References

World-Wide Intelligent Textbooks

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Abstract: New WWW technologies allow for integrating distance education power of WWW with interactivity and intelligence. Integrating on-line presentation of learning materials with the interactivity of problem solving environments and the intelligence of intelligent tutoring systems results in a new quality of learning materials that we call I³-textbooks. In this paper, we describe the development of ELM-ART, an I³-textbook for learning programming that can be accessed via Internet and that is based on the on-site learning environment ELM-PE.

Introduction

Distance learning with Internet opens new ways of learning for many people. Now, educational programs and learning materials installed and supported in one place can be used by thousands of students from all over the world. World Wide Web (WWW) and WWW browsers provide a good example of powerful modern Internet facilities. Using WWW, a novice user can comfortably browse the Internet finding required pieces of information in different locations worldwide. From the very early days of WWW, there were many trials to use WWW facilities for distance learning. Being a good general tool for Internet navigation, however, WWW and current WWW browsers are not specially designed for distance education. Thus, most existing educational WWW applications use only simple solutions and are much weaker and more restricted than existing 'on-site' educational systems and tools. A number of powerful technologies which proved to be very effective in 'on-site' education are still not implemented within the WWW framework. Two advanced educational technologies are of special interest to us: interactive hypermedia textbooks and intelligent tutoring systems. A prominent goal of the project we are working at is to integrate 'distance education' power of WWW with interactivity and intelligence offered by these advanced technologies.

From Simple Electronic Textbooks to Interactive Intelligent Textbooks

In the pre-computer society, a school or a university textbook used to be the primary learning support medium both in the classroom and at home. It is not surprising that several generations of researchers on computer use in education considered a textbook as a model for developing computer-based learning support tools. What is surprising is that a very big part of developed 'electronic textbooks' are no more than 'electronic copies' of printed textbooks: they offer the learner nothing more than access to the textbook content. Technically, current electronic textbooks (ET) are much better than their grandparents: first ETs used expensive mainframes and represented only text. CRT displays added graphics, personal computers made them cheap and available, multimedia technology added the possibility to present sound, video, and animation, and, now, Internet and World Wide Web bring the possibility of distance access. From the conceptual point of view, however, most ETs that are currently available on the WWW offer the student not much more than good printed textbooks that are available nowadays.

Advanced research on computer use in education showed that computers can be a much better learning support medium. To see the difference let us limit ourselves to programming language textbooks. Traditional printed textbooks give hierarchically structured presentations of programming language concepts and constructs. In addition to the presentation of concepts, good textbooks use a lot of examples--from simple expressions to complete programs--and exercises--from simple tests to programming problems. Simple electronic textbooks just serve the same information on-line, sometimes with use of simple hypertext technology. Two important features, interactivity and intelligence, can be added in more advanced systems.
Interactivity turns an electronic textbook from a passive into an active learning medium. Examples of adding interactivity are demonstrated by several 'interactive textbooks' [Boyle et al. 1994], [Fowler & Fowler 1993], [Meyerowitz 1995]. In addition to regular hypertext-based learning materials, some of these systems provide access to a programming environment with a program editor, an interpreter or compiler, and even a graphic program design tool. In such systems, all examples and problems are active teaching operations. The student can not only look at the example but also use the above tools to investigate it: to execute it, to change something, to execute it again, and so forth. The same tools can replace paper and pencil for developing and testing problem solutions interactively.

Another example of adding interactivity to textbooks is demonstrated by program testing and grading systems (e.g., Ceiligh [Benfordet al. 1994]). Ceiligh not only provides on-line access to the text of lectures and programming problems, but also can process student programs (i.e., problem solutions) and provide the student with important feedback. In particular, Ceiligh can test the correctness of a student's problem solution, measure its quality with several metrics, and report the results to the student. Such interactive feedback gets the students much more involved in the learning process. Interestingly, students often try to improve even correct solutions trying to get a better mark.

Further improvement can be achieved by adding intelligence into ET what means to make them perform some duties usually performed by the human teacher in the classroom. It is important to reduce the load of the teacher in the classroom and also in situations where a teacher is not available (which is mostly the case in WWW-based education). These aspects are investigated in the domain of Intelligent Tutoring Systems (ITS). Existing ITS for teaching programming can support the student in the process of problem solving, provide intelligent analysis of problem solution, and construct for each student an individual learning path, including individual selection of topics to learn, examples, and problems. Originally, ITS were considered as an opposite to ET technology. However, most current advanced ITS for programming (which are developed for the use in the real classroom) always integrate classic ITS features with programming environments, on-line course materials, and other features of interactive textbooks. For example, the ACT Programming Tutor [Anderson et al. 1995] provides problem-solving support, problem sequencing, and on-line course material. GRACE [McKendree et al. 1992] provides problem-solving support, on-line course material, and a program design tool. ITEM/IP [Brusilovsky 1993] provides intelligent course sequencing, adaptive on-line course material, solution checking, and an educational programming environment. ELM-PE [Weber & Möllenberg 1995] provides solution checking, intelligent program analysis, an educational programming environment, and intelligent selection of examples.

New generation ET should integrate on-line representation of learning material with interactivity of problem solving environments and intelligence of ITS. Such ET which we call I³-textbooks (where I³ means integrated + interactive + intelligent) really can provide a new quality over classic printed textbooks. A challenging research goal is to make I³-textbooks available on WWW. Among several other groups [Lin et al. 1996], [Nakabayashi, et al. 1995], [Nkambou & Gauthier 1996] we have started to work in this direction. In the following sections, we will give an example of how our ideas of I³-textbooks can be implemented in the domain of learning programming. We describe our research work on the development and implementation of ELM-ART, a WWW version of ELM-PE, that is currently one of the most advanced intelligent learning environments for programming.

ELM-ART (ELM-Adaptive Remote Tutoring)

From ELM-PE to ELM-ART

The knowledge-based programming environment ELM-PE was designed to support novices who learn the programming language LISP. It has several features that are especially useful when learning to solve problems in a new, complex domain. These features comprise a syntax-driven structure editor that helps beginners to code syntactically correct LISP expressions, example-based programming with examples chosen by the user or individually provided by the system on demand, explanation of run-time errors, stepwise visualization of the evaluation of LISP expressions and the cognitive diagnosis of LISP code based on the 'Episodic Learner Model' (ELM). All these features are described in more detail in Weber & Möllenberg 1995 and in Weber in press.

Though ELM-PE has been shown to be a very powerful tool for tutoring novices in LISP, there still exist problems. The goal of ELM-PE is to provide an environment under which the user can apply previously acquired knowledge in single programming tasks. But there is no opportunity for the user to repeat or to deepen
knowledge. The user has to refer to a common printed textbook that suffers from disadvantages stated in the introduction. This results in the need of integrating a textbook into the environment. Adding this feature to ELM-PE resulted in the development of the I-textbook ELM-ART, an adaptive, world-wide available tutoring system.

Integrated Textbook

The first step to an I³-textbook is to integrate an ITS and an electronic textbook into one single environment. ELM-ART contains a hierarchically structured ET that may be compared with common textbooks. Navigation is supported by links to neighbored pages and to a table of the contents of any desired node within this hierarchy. Additionally, a simple search interface helps to find special contents or topics. In addition to these old well-known techniques, ELM-ART provides adaptive navigation support to protect users from getting lost in the hyperspace. Among several known adaptive navigation support technologies [Beaumont & Brusilovsky 1995], ELM-ART mainly applies adaptive annotation of links. The system adds a dynamic annotation to any link presented to the user which tells the user what kind of page (e.g., text, example, or problem) will appear using a link and whether a link may be useful for the user [Fig. 1].

\begin{itemize}
\item Lektion 1
  \begin{itemize}
  \item Datentypen
  \item Funktionen
    \begin{itemize}
    \item Arithmetische Funktionen
    \item Listenzugriffsfunktionen
    \end{itemize}
  \item Eigene Funktionen
  \item Kontrollfragen zu Lektion 1
  \item Ergebnisse aus Lektion 1
  \item Glossar zu Lektion 1
  \end{itemize}
\end{itemize}

Figure 1: Part of the Table of Contents showing the hierarchical structure of the textbook. According to adaptive annotations the link to the page "Arithmetische Funktionen" is suggested to be taken next, whilst the link "Eigene Funktionen" is not recommended.

Interactive Problem Solving and Testing

An example in a textbook does not help very much if the user does not pay enough attention to it. That's why we want to provide an easy way for students to play with examples by integrating an enhanced evaluator into ELM-ART. This access is currently provided by transforming the text of any example into a link [Fig. 2]. When the user activates this link, the system loads the evaluator page, executes the example, and responds with the result or an error message [Fig. 3]. Employing the evaluator, the user can play with the given examples by modifying some pieces of code or by looking to step by step evaluation leading to a deeper understanding of the internal code evaluation strategy in LISP [Fig. 3]. Any occurring run-time error is explained by ELM-ART in more detail and more suited to novices than common LISP interpreters do. These explanations are sometimes augmented by hints that help correcting the error. The evaluator, supported by the above interface, has enough capabilities to serve as a simple but fully featured Lisp interpreter. Moreover, with its enhancements, the integrated evaluator of ELM-ART outperforms common LISP interpreters with respect to educational purposes.
Figure 2: Part of a page from the textbook concerning the problem "ZWEITES." Using the links, the examples are put into an interactive evaluator page where they can be modified and executed.

Whenever the user is asked to solve a programming task, he or she can check a solution by calling a testing tool that tests the code dynamically with some critical I/O-pairs. In case of an erroneous solution, the user is faced with some counterexamples. They may give a hint what type of error has occurred and where in the code it could be found. These examples may be tested interactively by the student in the evaluator at any time to see how the incorrect results are computed. This simple facility implemented in ELM-ART has been proved to be very powerful in several tutorial systems (e.g., Barr et al. 1976), (Weber & Möllenberg 1995).

Figure 3: Evaluation of the first example of [Fig. 2] based on the erroneous solution in [Fig. 4] using the stepper facility. Swapping FIRST and REST resulted in erroneously calling REST with the atom BROT.

Intelligent Program Analysis

According to our general approach, our I^3-textbook includes an intelligent environment that supports problem solving. For this reason, all programming problems are described in the textbook. Any page describing a programming problem supports the user in different ways. In addition to testing and evaluating code as described above, the user is supported by intelligent program analysis. If testing of a developed solution reports that it is still erroneous and the user is unable to find the error himself, he or she can invoke an intelligent program analyzer. As a result, the user receives messages that describe step by step which part of the code is erroneous and how to fix it [Fig. 4]. Therefore, the user is supported interactively at any time in solving the problem by testing and analyzing the solution as well as by an interface to the evaluator to execute some piece of code.
Meldungen:

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Du hast REST mit FIRST vertauscht!

Bitte hier die Lösung eingeben:

(defun zweites (list)
  (rest (first list)))

Implementational Considerations

System Structure

Yielding in the goal of integrating as many features as possible, integrated textbooks make use of large textual databases for the actual textbook and of extensive knowledge bases about the subject for tutoring and example analyzing. For adaptation to individual users, knowledge about the user (e.g., the learner history) is required as well. I-textbooks also employ several tools that require computational expensive algorithms handling the intelligent capabilities of the system. That is why fully featured intelligent textbooks are suitable only for expensive high-end computers. A reduction or limitation of any of these resources and features would not only result in a loss of comfort but also would lower the intelligence of the system. Since the user spends a lot of time in reading and thinking, the time between single user requests is rather high compared with computation periods caused by these request. Therefore, employing one high-end computer per student is an enormous waste of computational power and of physical resources. The only way to avoid either a loss of quality or a waste of money is distributing the system following the well-known client-server paradigm.

If we want to provide world-wide availability of I-textbooks, the WWW is definitely the best choice to do that. This world-wide information service is supported by several front-end clients on nearly all common computer systems. Since these WWW-browsers can be run with small amount of memory, disc-space, and computational power, this kind of interface provides cheap world-wide access.

Platform of ELM-ART

ELM-ART is implemented based on CL-HTTP described in [Mallery 1994]. This tool provides a fully featured HTTP-server completely implemented in Common LISP and has shown to be an optimal platform for our purposes. CL-HTTP offers a Common Gateway Interface to handle incoming URLs from all over the world via the Internet. Any valid URL is associated to a response function implemented in LISP that is called by the server on an incoming request. The received URL and enclosed form values that may contain an arbitrary amount of
incoming data are submitted as function parameters. Therefore, the response function can answer the request by using Common LISP standard I/O-functions to generate an HTML page as an adaptive response. Since a LISP function is called to handle the request, any desired information can be included to this page very effectively and, of course, any arbitrary interactive or intelligent tool can be integrated this way. Because the communication between client and server is so flexible, the system can be highly interactive and adaptive meeting exactly the requirements of I3-textbooks.

Selected Examples

The possibilities rising from a programmable WWW-server are enormous and not at all exhausted by ELM-ART. By explaining some special features integrated into our implementation we want to give an impression of the facilities that concern advanced adaptive text display, higher interactivity with complex data, integration of external tools, and enhanced feedback (URL of ELM-ART http://www.psychologie.uni-trier.de:8000/elmart).

Adapting Pages. This is facility is the basic part of our I3-textbooks. We avoid static pages as in older textbooks and make them adaptive by computing the page on the fly when the user requests it. For this purpose, our actual textbook is represented in a database that can be accessed via page identifiers to receive an outline page. These outline pages contain--besides the textual information--adaptive formatting options to enable the system to build an HTML-page based on the user's interaction and learning history. When the page is created it will be sent to the user who will not notice at all that the page was just generated for his or her individual purposes [Fig. 1].

Interactive Evaluator. To integrate the evaluator, we provide a form-based interface by which the user can submit own LISP code for evaluation. This is done by inserting HTML fill-out-forms in the page to be filled with LISP code by the user. By clicking a submit button, a HTTP-request attached with the form-contents is sent to the server. The associated LISP function calls the evaluator while its output is redirected to the remote client. At the bottom of the evaluator output, a new fillout form is inserted so that the user gets the feeling of a real LISP interpreter (listener) [Fig. 3]. Current HTML-standards and available network throughputs unfortunately do not allow a proper implementation of a real stepper facility. So, we decided just to show complete, scrollable traces of the execution that can be received by clicking a special submit button.

Intelligent Solution Diagnosis. The implementation of an interface to the diagnostic part of the I3-textbook is even more difficult. While the input of the solution can be handled similar to the evaluator interface, the output of the diagnosis is more difficult to handle because it contains helpful information and hints up to the complete solution that should be presented step by step to animate the user to work out as much as possible on his or her own. We solved this problem by enclosing the diagnostic feedback into a scrollable window so that only one message is visible at one moment. The user can look at all messages step by step and can simultaneously improve the solution according to the pieces of information just read from the feedback window [Fig. 4].

Conclusion

The system ELM-ART described in this paper provides an example of a new kind of an electronic textbook. As many others textbooks available today on the WWW, ELM-ART provides remote access to a hypermedia-structured learning material which includes explanations, tests, examples, and problems. Specific features of our system include the possibility to play with examples, to solve the problems, and to get intelligent support which usually can be provided only by a human teacher. ELM-ART integrates the features of an electronic textbook, a learning environment, and an intelligent tutoring system. It is a real I3-textbook (i.e., integrated + interactive + intelligent textbook). We consider adding interactivity and intelligence to WWW educational applications to be an important direction of research.

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A Computer-Based Student Welfare Information Support and Help System

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Abstract: Providing counselling and general welfare information to students is very important in higher education. The computer-based Welfare Information Support & Help System (WISH) is a layered multimedia project which aims to provide a range of technological access points to counselling for students at University. The main ‘layer’ of the project is a Macromedia Director™ advice system which users may consult on a stand-alone Macintosh or PC. At the core of the PC-WISH is a “shell” which can be configured for any University or other typical higher education institution. The shell uses html style documents for institution specific information, therefore enabling a more accessible but less interactive ‘layer’ accessible through WWW on the Internet. The WISH system has also been used as the storyboard for a CD-I version thus providing a less accessible but more televisual ‘third layer’. The system is currently being evaluated in 3 UK Universities.

Introduction

It is widely recognised that higher education institutions must provide better systems for helping an increasing number of students to cope with the increasing pressures upon them. To be effective and accessible this support must be integrated within the mainstream of the information management and dissemination structures of the institute. The computer-based student Welfare Information Support & Help system (WISH) project is directed toward the use of multimedia and network resources to address the pressing need of students and their advisors for better access to information about sources of help for them to manage their academic lives. They need to be able to access that information, and thereby the help they require, in a flexible and friendly way. We believe that even the most useful information services currently provided by Universities falls far short of the potential offered by the state of the art of multimedia and network technology.

The computer provides an interesting channel for advice and support as most higher education institutes have readily accessible personal computers which they network and manage for their students’ work. Indeed, there have been numerous recent experiments based on personal computer ‘advisor’ programs. Many systems focus on health issues and support for specific health related problems such as obesity [Burnett et al. 1989; 1992], nutrition [Levitan et al. 1992], drugs [Bosworth et al. 1991, Henningson et al. 1986] or sexual behaviour [Ochs et al. 1993], and AIDS [Schinke et al. 1989]. Most of the programs are based on computer assisted instruction models or in some cases on a decision-tree questionnaire interface. Few use much of the potential of multimedia resources. The reports of these systems tend to agree that they have a useful role in providing information, education and supportive advice to users, whilst noting concerns that their effectiveness may be limited in the absence of suitable social support networks which are often associated with successful counselling and advising [Agras et al. 1990]. Nevertheless, the potential cost-effectiveness and ready availability of computer-based support resources is clearly very exciting. All higher education institutes are now working on projects which make use of the huge potential of the Internet for management, information provision and publicity. For most institutions this means setting up some form of campus wide information system - most typically using the World-Wide Web and its associated browsers. Some have begun to explore how they may integrate advice and support services to their students within this framework.
The computer-based Welfare Information Support & Help system (WISH) is a prototype of a multimedia welfare information service. The experimental WISH prototype has been implemented on an Apple Macintosh computer using Macromedia's Director™ (henceforth PC-WISH) and has already been evaluated by a sample of counsellors and potential users in Sheffield University. The architecture of the PC-WISH prototype provides a “shell” for a counselling support system which could be used across the higher education sector. The shell imports institution specific information in the form of “marked up” text files. The mark-up language we use is compatible with the World-Wide Web standard .html. These files may therefore be delivered independently to students over the Internet as a WWW-WISH. Furthermore, the shell has been used to storyboard a CDI version, henceforth CDI-WISH.

The first phase of the WISH project has focused on the exploration of the issues involved in providing welfare and counselling support information in a multimedia form.

System Development

The first phase of the project had two conflicting strategic development requirements. (1) to fully explore the needs of counselling staff and users of a system of this kind, unconstrained by the details of the delivery mechanism. (2) to produce a prototype and have it evaluated against (1) within the first six months, to fit in with a two year final development timescale.

To minimise the conflict between these requirements we spent the first 3 months of the project as an entirely “paper based” development. This kept the design well away from the computer and enabled the developers to stress to the counsellors the need to think about what should be done (via clients needs) rather than what could be done (via their understanding of the computer’s potential). The key modules and ideas were specified and storyboarded on paper during this phase. For the rapid prototyping ‘alpha’ phase of the project we chose to develop the initial system on the Macintosh, using Apple’s own HyperCard 2.2. To further speed up development of the prototype content was embedded within the system at this point.

During the initial design phase, the key priorities for the ‘alpha’ PC-WISH identified by the counsellors were firstly: to provide sources of help and information for students who were considering making an appointment with a counsellor. This would enable students, while waiting on the waiting list, or before joining it, to help themselves. Where possible students should be able to employ self-help strategies, or to seek alternative help where appropriate. Secondly, a support system should prepare potential clients for counselling by explaining the context and scope of the counselling facility. This would allow the time spent on the waiting list to be more constructively used and better understood. Therefore the modules that were designed and prototyped first for the system were to do with an “Introduction to the System”, “Introduction to the Counselling Service” and “Problem Focus”. We have already run a small but detailed evaluation of the current prototype with potential clients as well as engaging in a continual process of review with counselling experts and professionals.

The next stage in the development was to consider the delivery system required for the ‘beta’ WISH system. Apple’s HyperCard™, whilst an excellent rapid prototyping tool, is in many respects unsuited to deliver this product. Its current version handles colour and graphics awkwardly, is slow and insufficiently robust. It is also limited to the Macintosh™ platform. We chose to reimplement our PC-WISH presentation and data management system in Macromedia’s Director™ (v4.0) as a quality, dual-platform standalone and as an ideal “interface client” to WWW and CD-I development formats. The rational reimplementation to the beta prototype enabled us to properly review the “shell” features of the system and to move it dual-platform to a MS- Windows™ PC version. The PC-WISH system which resulted from this work integrates fairly well with complementary layers of WWW-WISH (as .html documents) and CDI-WISH (as the CDS, storyboards).

Views of the PC-WISH System

After a brief introduction to the PC-WISH system users are presented with a simple choice point screen [Fig. 1]. From this they may choose to find out more about the project and its aims, they may ask for help about the
system, ask about the University's counselling service or enter the section which focuses on a small set of problems in detail. These problems include: issues related to depression, exams, HIV and sexual orientation.

Figure 2 simply presents an illustrative graphic of a counsellor in the office setting from the ‘introduction to the counselling service’ section. This sort of illustration is felt to be helpful to enable the students to recognise and contextualise the counselling situation. From here on down into the system we adopt a standard "toolbar" of controls for the users to navigate further. The map button provides users with graphical navigational cues to where they are within the system and how they got there. The problems button returns users to the key problems choice point shown above. The graphic button returns the user to the main choice point for this section (in this case, the who, what, where ... of the counselling service; in the case of the problems, the "thought bubbles" cartoon - see below). The help button provides context sensitive help. The page indicator shows them how long in pages the current section is, and where they are within that. The left, right and return arrows (to the far right) move them left, right and to the beginning of this current section. Tools which are logically unavailable at this point are deselected (greyed or coloured out).
In figure 3 we see a user selecting the hot text "Student Advice Centre" which is emboldened to the left and a pop up window with further information about the student advice mentioned. In hot text navigation we have tried to avoid a navigation out of the current screen context, which feedback from users indicates to be very disorienting. This text is marked up in .html style as a text document and is read in to the shell system by the institution author to create the PC-WISH stand-alone. This .html like text can then be used by the institution’s World-Wide Web service to deliver the highly institution specific information to students (or the world) via the Internet.
Figure 3. Illustration of a "hot text" popup window.

Figure 4 presents a key choice point for one of the problems in the ‘problem focus’ module. In this case the problem of Exam Anxiety is cartooned to enable the user to consider problems related to a difficulty to prepare for exams, panic, problems with a disability or some other worry about the process. Each text bubble is a button which leads the user onto a screen such as Figure 5.

Figure 4. The Exam Anxiety "thought bubbles" cartoon choice point.
In this example [Fig. 5] users with a problem preparing for examinations are invited to consider relaxation techniques which may help them. The hot links in the text bring up pop-up windows that explain the details of the techniques proposed and how they may help.

Figure 5. A sample screen from ‘Exam Anxiety - Preparation’.

Figure 6. A sample screen from the CDI-WISH ‘Depression’ module.

The material managed by the PC-WISH system presents a graphic and interactive set of information to the user of a personal computer. We have noted that students may find this interaction difficult, as they may have trouble pointing-and-clicking with the mouse, etc. This is much harder for the WWW-WISH experiment in which the
graphic presentation is much more limited by the current state of that medium, and the delays in network access. By contrast, all students are comfortable with television and are quite used to a televisual presentation of similar information. To explore this further we produced a CDI version of a segment of the PC prototype. For this system the PC version provides the storyboard that the CDI developer works to. The CDI version takes much of the written text of the PC system and speaks it to the user, with moving graphic and video sections acting primarily as a focus of attention for the user. Most text is in very brief summary bullet points and menu items to interact with. Most of the information is provided to the CDI user via a spoken voice over. It must be noted that the CDI-WISH is currently only a demonstrator level system which has been produced by a commercial consultant as a sample of the potential of this more televisual medium.

Conclusion

The really interesting contrast in support of these three complementary layers is most visible in their televisual interaction. The WWW-WISH has the least televisual interface for the user, in that it is made up of (perceptibly) many different chunk of (mainly) text connected via hypertext links. The CDI-WISH is the most televisual, in that it runs like a television programme that you can interact with. The interactions are similarly limited as the web version but the interaction with exactly the same information is very different. The PC-WISH is clearly between these two extremes, and as user experience with computer based information services matures, and indeed the network and video technologies converge, we expect that this will provide the most useful core to this form of support service.

It seems from published literature that there are currently no counselling information support systems available to the European student community at the present time. The systems prototyped in North America, which we discussed above, are very different in scope from the WISH system. Furthermore, whilst it has been shown in some studies that simulated computer-aided counselling has been proven to be less effective by clients than if clients meet with another person [Fernandez 1986, Arbona 1989], the results from North American support systems, as noted in the introduction, are very much more positive. The key to the success of these computer systems seems to be in their integration with (and complement to) existing human support services. The PC-WISH shell system is currently being evaluated in Sheffield and two other UK universities.

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References


The Role of Electronic Communication in Supporting Beginning Teachers

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Abstract: The largest post graduate initial teacher education course was introduced by the Open University in the UK in February 1994. The course is innovative in a number of ways: it is the first large scale distance taught pre-service course in the UK; all students are loaned a computer for the duration of the course; and computer conferencing is used extensively for communication between students, part-time tutors and the course team. In this paper the use of the computer conferencing element is described and evaluated. Ways in which electronic communications can be developed for this to be a truly effective medium for supporting the development of beginning teachers' competence and confidence.

Introduction

In February 1994, 1100 primary and secondary students began the first Open University postgraduate course for initial teacher education (PGCE). Many of the students have been given access to a teaching qualification which, for a number of reasons, was previously unavailable. For example, some had family commitments which either for financial or domestic reasons had not allowed them to take a year to spend time in a traditional teacher education institution. The course is an 18 month distance taught part-time course in which students are sent text based materials, set books, audio and video cassettes. In addition an Apple computer complete with a Stylewriter printer and Clarisworks are loaned to students as part of their study materials with the intention to support the development of their IT competence.

However evidence from other Open University courses using electronic communications suggested that the computer could provide added value [see Mason 1995]. It was thought that students' access to their peers as well as their tutor and members of the OU course team could be increased if a modem with communication software was added to the package. At that time the Open University was using CoSy with some students following technology courses and using PCs. PGCE students were not accustomed to a command line interface and also many were using computers for the first time. Introducing them to CoSy and expecting any reasonable level of usage was highly improbable, so with some negotiation with the University's Academic Computing Service unit it was agreed to send students the conferencing system FirstClass, which uses a graphic user interface and was more recognisable and therefore more likely to be taken up. As the course writing was well underway, it was not possible to integrate the use of the computer fully into the course, so the decision was taken that FirstClass would not have a teaching function but would provide students with a community that mirrored to some extent the community they would be part of on a traditional face-to-face initial teacher education course.

The first cohort of students came on-line in January 1995, nearly a year after the start of the course which would finish in July 1995. It had been hoped to set up the conferencing earlier but operational problems delayed the start by several months [see Selinger 1995]. However more than 85% of students logged in to the system and it has being judged successful by those who used it. Table 1 gives some indication of the frequency with which students logged-on. (This data is based on the response from the student survey conducted by the Open University at the end of every course in its first year of presentation.) The second cohort of students came on-line in September 1995. The third cohort will start with FirstClass in April, some two months after starting their course, thus indicating the importance the course team feel this aspect of the course has become. Patterns of logging on from early data suggest this frequency has increased. Speculation by the course team put this down to longer access to the system, and this conjecture will be tested with questionnaires to all 1995 students and some follow up interviews.
Why electronic communications?

Although achieving personal development and pedagogical goals justified the investment in the IT provision, it was felt that the course could be enhanced by students communicating more frequently and more easily than was traditionally the case in a distance learning course. Teaching experience for many students can be tiring and stressful, and the need for peer and tutor support in addition to mentor support is crucial. Many Open University students would be the only student in initial training in a school and there was concern that they might feel isolated. An electronic support network could address this. Beginning teacher networks had been set up in other parts of the world and evidence has shown them to help students in their reflection and developing understanding of what being a teacher involves [Beals 1991, Coyle & Harrison 1993]. There have been some small pilot courses run in the United Kingdom reported at a conference run by the National Council for Educational Technology [NCET 1994] and many of the findings from these studies were taken into account in deciding how the Open University PGCE conferencing system would be structured.

Students were sent a diskette and an accompanying handbook with instructions on how to log-in and describing the protocols of using an electronic communication system. When students log-in for the first time they find on their desktop a mailbox for private mail; a bulletin board on which important notices are posted on various subject or regional based notice boards; and a meetings room folder. The metaphor of room is followed throughout the sub-conferences found inside the PGCE meetings room. There is a main lobby in which general 'coffee time' and 'corridor' conversations can take place. The course structure is mirrored in the range of conferences on offer in the meetings room. Students are allocated to a tutor group with about 15 other students. These groups are based in one of the twelve regional centres of the Open University across the UK. Students elect to follow either a primary course (with a choice of lower (ages 5-8) or upper primary (ages 7-11)) or a secondary course selected from one of seven curriculum areas - mathematics, English, science, history, modern foreign languages (French), design and technology, and music. Tutor groups are either mixed primary or mixed secondary. Students have access in FirstClass to a tutor group conference, where they can communicate in a closed forum with members of their tutor group and their tutor with whom they meet face-to-face on 5 occasions during the course at a tutorial and 4 times a year at regional day-schools. Students also have access to a regional conference where they can discuss various aspects of the course with tutors, the staff tutor and fellow students from their region. Each regional conference can only be accessed by students assigned to a particular region. Regional staff tutors who are appointed to administer the PGCE in a region are encouraged to initiate discussion prior to each of the four day-schools or following on from them so that students can continue the debate and discussion. Students are encouraged to initiate topics for discussion in all these forums.

In order to keep the discussion areas free of technical queries about the use and operation of the system, there is a conference assigned specifically for problems of this nature called 'ACS helpdesk'. Since students are in mixed subject tutor groups, either primary or secondary, they have limited face to face access with other students following the same course line. For example in any secondary tutor group there might be students from each of six subject lines, and perhaps only one or two of these will be following the same line. To increase access to other students, there are subject 'rooms' for each secondary subject line and also a primary 'base'. In addition to these conference areas there is a staff room conference where tutors and the Open University course team can discuss conference moderation issues, share ideas and communicate information that had previously been distributed through the post or by telephone.

During the first few weeks of coming on line well over 50% of students in the first cohort logged on and there were around 30-50 entries a day. On average there were ten students on-line at any one time during the evenings and often more at weekends. FirstClass has a useful facility whereby the 'history' of each message is available.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>data missing</td>
<td>4</td>
</tr>
<tr>
<td>daily</td>
<td>5</td>
</tr>
<tr>
<td>2-3 times a week</td>
<td>17</td>
</tr>
<tr>
<td>once a week</td>
<td>25</td>
</tr>
<tr>
<td>less than once a week</td>
<td>27</td>
</tr>
<tr>
<td>not at all</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 1: Frequency of logging-on
which enables a user to find out who has read a message and when. This often numbered more than 100 in conferences where all students had access, revealing that the number of posted messages is far less than the numbers of students participating in some way. This is comparable to face-to-face seminars and lectures. In a large forum probably only a handful of people will offer comments or questions and this will be true for any group of people; some are naturally more verbose than others, the rest are listening. The 1995 students are more active and this is thought to be because they have had longer to get used to the system.

In an article in the Scientific American [Sproull and Kiesler, 1995] it was found that those who contributed to computer conferences became more confident when contributing in face-to-face meetings. However Mason [Mason 1995a] found that in a pilot Open University philosophy course trialling computer conferencing; 'some students feel that conference interactions are dominated by highly articulate students and this is off-putting.' (p7). Many PGCE students interviewed during the regional monitoring process reported finding FirstClass helped them to feel a greater part of this community, thus supporting Sproull and Kiesler's findings. Students felt they were not alone in their struggles and many were willing to share these as well as their triumphs. These extracts below about students' final school experience illustrate this dialogue:

My attempts to stimulate some more able year 8 have also failed, largely because of logistic difficulties but also because I planned too ambitious a course.

I feel defeated. Advice from mentor - "Sit on them, don't let them get the better of you" . Great advice, I just seem to have problem putting it into practice. She was impressed when I said I had got most of the class to write up an investigation yesterday. I did not feel I had achieved anything just failed a little less!!

I feel much more in control this time around even though I dread the lessons that are being observed and feel that I may be getting through to one or two of the more difficult kids, especially as one called me a right bitch the other day.

I also had extreme problems with my Year 9's at the beginning of this TP. My mentor and Head of Dept wanted me to come down very firmly and insist on silence and give them a boring but accessible task for a lesson, to re-establish control. I rebelled and insisted on doing a brainstorming exercise and some group work (unheard of with set 4!! at my school). and unbelievably it worked.

I have found that ignoring poor behaviour and praising where it is due works really well. If they are really bad I throw them outside the door for a while to calm down but I have always managed to get them to want to come back in. It's boring having a tantrum by yourself!

The messages reflected the concerns of the students at different stages of the course, so as well as requests for advice on issues of classroom management during the final school experience which led to discussion like the one above, discussion would also take place about the next tutor marked assignment (TMA) as it became due; and teaching resources were offered and exchanged. Many of the worksheets offered were of a high quality reflecting the students increasing competence with computers. There were also discussions on ethical issues like the dissection of animals and insects in science lessons.

As the date of submission loomed ahead, discussion turned to the nature of the assessment portfolio and support and advice was offered which no doubt added to the excellent quality of the portfolio contents. Once portfolios were out of the way then the discourse moved to the thorny area of job hunting. Discussions included what to say at interview, an analysis of the questions asked and what might be adequate responses, what answers helped them to get a job, what to wear and what sort of jobs to apply for. Sympathy and support for those who failed to get a job after interview was regarded as crucial to student morale.

Benefits of electronic communication

The benefits of this mode of communication are two-fold; the students can be supported in their study of theoretical aspects of the course and they can be supported in developing their teaching. Beals in a survey of beginning teachers using an electronic communication network reported that they found it to be 'most effective as a source of emotional support and as a means of achieving a broader perspective on education.' [Beals 1991 p77]. The evidence from the PGCE student survey reveals that moral support was indeed rated highly, but
'seeking information' was rated nearly twice as high. Of the respondents, 553 had logged-on to FirstClass and responded to the items on the use they made of and value they assigned to FirstClass [see Tables 2 & 3].

<table>
<thead>
<tr>
<th></th>
<th>regularly (%)</th>
<th>occasionally (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>seeking information</td>
<td>33</td>
<td>47</td>
<td>80</td>
</tr>
<tr>
<td>clarifying issues</td>
<td>12</td>
<td>33</td>
<td>45</td>
</tr>
<tr>
<td>moral support</td>
<td>12</td>
<td>29</td>
<td>41</td>
</tr>
<tr>
<td>sharing ideas</td>
<td>12</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>contacting students</td>
<td>13</td>
<td>26</td>
<td>39</td>
</tr>
<tr>
<td>contacting tutor</td>
<td>5</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>sharing resources</td>
<td>5</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>sharing techniques</td>
<td>2</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>contacting staff tutor</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>contacting course team</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2: Uses of FirstClass

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>getting information</td>
<td>67</td>
</tr>
<tr>
<td>moral support</td>
<td>42</td>
</tr>
<tr>
<td>keeping in touch with students</td>
<td>37</td>
</tr>
<tr>
<td>reflection</td>
<td>33</td>
</tr>
<tr>
<td>keeping in touch with tutor</td>
<td>25</td>
</tr>
<tr>
<td>sharing teaching resources</td>
<td>18</td>
</tr>
<tr>
<td>help with planning</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 3: Value of FirstClass

Benefits to students' study of the course

Students have greater access to the course team and to other tutors, some of whom will be subject specialists in their area, and who can be involved in different aspects of a course as needs arise. In a smaller survey of some 300 students they were asked to state which particular conference they had found most useful. Of the 262 who had used FirstClass, 36% reported finding the subject conferences the most valuable. The course team have started to experiment with ways of enhancing the system. For example guest speakers have been invited to contribute to the history conference and students have been able to have a dialogue with an expert who is not the conference moderator. The science and mathematics students have been sent a paper electronically to read about the teaching of mathematics in science lessons and the use of scientific concepts as the content for problems set in mathematics lessons. They were given a week to read the paper and to consider the issues and then the conference was opened for a discussion of the issues they believed to emerge. The debate has been vigorous and students who had previously only read messages have been contributing regularly in this specially set up conference Mason [Mason 1995a] reported that students on the philosophy course discussed earlier believed computer conferencing had advanced their understanding of the subject particularly with respect to structured interactions. This has certainly been reported by students in the maths/science forum. The opportunity to continue and extend debate from day schools or tutorials has been taken up by some. In one day school, the mathematics students had asked to discuss the problems of trying to teach pupils in mixed attainment groupings. A heated debate arose in which the discussion centred around whether it would be better for low achieving pupils to be taught separately from their higher achieving peers so they did not become disillusioned because they were unable to complete the same work, or was the effect of placing them in the 'bottom set' a labelling which gave them a reason to continue to underachieve and a place where they were not expected to perform well. The debate was not resolved at the day school (it is a debate which is continually on the agenda in UK education), It did not stop there but continued in the mathematics conference on FirstClass and enabled others, who had attended day schools in other regions, access to the debate and an opportunity to contribute which they would not have had without the electronic communication medium.

Benefits in learning how to teach
Many PGCE students have reported how valuable the ‘General Chat’ facility has been (another facet of the PGCE meetings room set aside for less course specific discussion) for enabling communication with others on any matters of interest of their choosing. Networks like these can give beginning teachers an insight into collaborative working. Teachers experimenting with ways of improving their practice believe the interest and support from colleagues to be an important factor. Having to articulate their thoughts in words can help students consider the issues involved in teaching more deeply and the peer support network can facilitate this development. Merseth [Merseth 1992] writing about an electronic network of newly qualified teachers who all graduated from the same teaching course at Harvard gives an example of how this network was being used:

I remember discussing discipline, teaching methodologies, how to stand up to an unreasonable administrator,... - it as amazing how real the problems being shared on the network were. It was also amazing how frequently we would refer back to required texts from Harvard in our discussions, and yet in a completely new light. [Merseth 1992 p679]

Students can be involved in several discussions at once, something difficult to achieve in real time face-to-face discussions, and because they are recorded in text, items can be accessed at other times. Beals (1992) found that such messages were also longer than equivalent speaking times (215 words compared to about 12 words). The second cohort of students have certainly become more verbose as they continue to use the system and many messages are filling two screens where they had only filled one in their initial venture. The role of the conference moderator may well have contributed to that. Learning how to moderate conferences has been an 'on the job' experience for all of the course team. However by sharing ideas and practice, they have found ways to encourage and praise students to the extent where their contributions are less tentative and more confident as these two examples from one student illustrate:

(November 11) My partner school seems to be fairly impressed with the ST(P) series, edited/written by Chandler and Bostock and published by Stanley Thornes. There is a book for each year (a bit pricey I guess if you really want only one book for the whole of KS3) and a choice of books in that year e.g. there is a 2A and a 2B which are for higher and lower achievers respectively in second year of secondary (Yr. 8). Within the book there are tons of examples which are graded and include lots of meaty problems. Within a topic there will be many exercises as the topic is built up e.g. Ch. 4 might contain Ex. 4a, 4b, 4c,...all the way up to mixed exercises at end of chapter. After all the changes to Nat. Cur. my school is wishing that it had bought these for each year of KS3 and 4. (They are also impressed with Rayner, Higher as a revision guide for GCSE).

(February 25) My TIAS school had an organisation of complete mixed ability tutor groups; band a or b was a general setting based on tests done on the induction day in the July previous to arrival at the school (a lovely way to be introduced to your new school) and then within band a or band b there were sets for most of the subjects. Thus a pupil could be in band b (the better band!) and then in set 1 for maths, set 2 for English, set 3 for French. A pupil in band a (the weaker band) could be in set 4 for maths and set 5 for English. The pupils who ended up in front of you in maths might not be together again for any other subject. At least there were no sink classes, and pupils were able to 'shine' somewhere.
What did emerge though, was that pupils had been banded mostly according to their English abilities and it did happen that reasonable mathematicians ended up in the weaker sets of the lower band because their English was weak, and conversely that able pupils language wise, in the more able band could not cope with the maths there.
A confusing set up and quite confusing to explain. It doesn't answer your questions. Sometimes the attitude of the teachers of the bottom sets seemed to be to aim low, and only give the pupils a diet of arithmetic, arithmetic and more arithmetic. I've just read somewhere in Block 6 that teachers do not give weak pupils access to a more interesting curriculum, believing that they wouldn't be able to do it anyway so why bother - stick to the basics.

Cross-phase interactions have also been made possible; for example, primary students have talked to secondary mathematics students about the way they teach a topic on area, and they have also discussed the teaching of basic numeracy skills. This is a forum for discussion in which students rarely have the opportunity to participate in traditional institutions.

Overcoming potential problems
One problem can arise when sending attached files when students are working on different computer platforms and are sometimes unable to be translated easily. The Open University PGCE model has been particularly successful because students are working on the same machines using the same software, thus facilitating wide scale publication of notes to support their initial use of the system and also the same package (Clarisworks) in which to write and send attached documents. As stated earlier, this has resulted in students exchanging worksheets to support each other in their school teaching experiences, and because they use the same software and computer, students have either used these sheets either unchanged, adapted them for their own situation, or have been motivated to produce their own.

Another problem that has been a de-motivating factor, and which has been overcome for the 1996 students, is the reliability and speed of the modems. Students were given 2400 baud modems because of the cost factor in providing the whole computer package. However the cost of modems has plummeted and students are now receiving 14400 baud modems. It is envisaged that the speed of these modems will reduce costs to students. In the UK there are few systems which offer fixed rate local call charges and although students are given advice on how to reduce on-line times, the cost has been a prohibitive factor.

Continued evaluation

1996 students will benefit from the experience gained to date by the course team and tutors. Tutors are given more detailed advice about how to encourage students to join in the electronic aspects of the course and contribute regularly and past students who are clamouring to stay on-line as alumni are being invited to support new students. The benefits to be gained by computer conferencing are beginning to emerge, but more research is planned with semi-structured interviews with 1995 students and monitoring their use of the system throughout the course in addition to the questionnaires. The interviews will focus on a group of 25 students use of FirstClass in terms of the way their views of teaching have been affected as a result of their interactions with others as well as the nature of support the system provided. Both high and low users will be interviewed so that ways of encouraging more students to contribute in some way can be found along with new ways to use the medium in order to enhance students understanding of the teaching and learning process.

This message to a regional staff tutor sums up the value to one student of FirstClass

One of the unexpected joys of the course was the loan of a computer and modem for the duration of the course. ... The modem link allowed me to tap into a vast information and support network. The distance in this so-called distance learning course shrank to nothing as anything from a friendly chat to a deep discussion with a subject specialist was available via my keyboard. The only casualty was my telephone bill!

References


Incorporating Asynchronous Collaborative Learning into an AS Engineering Degree Program for Home-Based Learners: Challenges, Strategies and Tools

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Abstract: Northern Virginia Community College (NOVA)'s Extended Learning Institute (ELI) and faculty at NOVA's Annandale campus are developing distance education engineering, mathematics, chemistry and physics courses leading to an Associate in Science engineering degree. Incorporating asynchronous learning networks (ALNs) into course design enables the development of courses that integrate interaction and collaboration with self-paced, independent modes of learning. Developing such a program for home-based community college students presents a number of other significant design challenges, including maximizing access to learners, assuring portability of courses to other interested institutions, developing effective physical science and engineering laboratory activities, transmitting graphical content, representing scientific processes instructionally, and developing faculty competence without requiring universal expertise. By using commercially available software products for such functions as computer-mediated communications, graphical content transmission, and process representation, multimedia course materials can be affordably developed and incorporated into distance education courses for home-based learners.

Creating asynchronous learning networks to support interactive, collaborative learning

Work in engineering and the physical sciences increasingly involves collaboration and teamwork. Most engineering employers are not satisfied with the communication or teamwork skills of recent engineering graduates [Agogins, 1995]; engineering educators recognize this need and are calling for appropriate curricular reforms and alternate delivery systems to enact them [National Research Council, 1995; National Science Foundation, 1995; American Society for Engineering Education, 1994]. New technologies now enable the creation of computer networks which link dispersed participants in learning activities. These learning networks have great potential for improving traditional instruction and for supporting innovative teaching and learning methods by facilitating communication and collaboration among learning participants [Harasim et al. 1995; Kearsley 1993]. One major initiative in this area, funded by the Alfred P. Sloan Foundation, involves over two dozen U.S. universities and community colleges which are currently implementing projects using asynchronous learning networks (ALNs) to support teaching and learning. ALNs provide access to remote resources at the learner’s convenience, not dependent on synchronous, real-time communication. A resource can be a human (peers, tutors, faculty), a facility (e.g., libraries, laboratories at a distance), or a product (e.g., software-generated simulations, work products of remote collaborators). Assuming that learning follows from access and interaction, ALNs increase the opportunity for interaction and collaboration among participants in the learning process [Mayadas, 1994]. ALNs can be used to supplement classroom courses for on-campus students using local area networks [e.g., Oakley 1995], support learning for both on-campus and remote learners using the World Wide Web [e.g., Bourne 1995], or deliver instruction to remote learners using emerging technologies such as asynchronous transfer mode (ATM) or Integrated Services Digital Network (ISDN) lines [Harris 1995; Vigilante 1995].

Combining interactive, collaborative learning with self-paced, independent learning

In NOVA's project to develop a distance education engineering degree program for community college students, the principal challenge has been to incorporate interactive, collaborative learning into a distance education delivery system designed for self-paced, independent learning. As NOVA's distance learning administrative
unit, ELI has a long track record of success in implementing non-traditional programs and delivery systems, especially technology-based instruction, for independent study or individualized learning. Since 1975, ELI has enrolled over 130,000 students and currently offers 90 college credit courses in a wide variety of academic subjects. ELI averages around 3,000 enrollments per semester (roughly 600 full time equivalent (FTE) students) and around 2,000 summer enrollments (425 FTEs). ELI's program supports independent learning by featuring self-pacing to give students substantial control over their pace of study, continuous enrollment to maximize access, and utilization of multiple media and technologies such as print, video, computer, audiotapes, and voice mail. These features allow students to do most of their studies from home, although several on-campus visits for tests or laboratories are usually required. While independent, self-paced learning has been effective for ELI students, integrating interactive and collaborative learning experiences into this approach is necessary to provide opportunities for learners to build the teamwork and communication skills increasingly in demand by engineering employers.

Developing mathematics, science, and engineering courses for home-based learners that incorporate asynchronous collaborative learning into self-paced, independent study courses has involved grappling with several specific design issues. Many of these issues are common to many or all distance education programs. For instance, one of our global design parameters has been that each course must be at least equal in quality to on-campus offerings, to ensure the credibility and acceptability of the program. Other issues are more specific to our particular program or type of program, for example the need to provide maximum access in keeping with ELI's mission as a community college unit.

Providing maximum access for home-based learners

ELI students are not geographically isolated from NOVA's five campuses, but work and family responsibilities along with external obstacles such as the region's notorious traffic congestion prevent many of them from regularly attending on-campus classes. Integrating computer interaction into courses serving home-based learners means being restricted by the minimum computer configuration to which students are likely to have access. Also, like most community college programs, ELI tends to serve cost-sensitive students whose level of computer competence varies widely and in many cases is relatively low. This combination of learner characteristics rules out many higher-end commercial products as too expensive, high-powered, or cumbersome to use. For instance, in the first phase of our project we experimented with the use of the groupware package Lotus Notes™; although Notes is a powerful product with many beneficial features, it was too expensive, difficult to learn and complex to administer for our purposes [Sener, 1995]. Instead, ELI relies primarily on technologies that are relatively simple, reliable, affordable, and widely available. Commercially available software products that support computer-mediated communication (CMC) and other functions necessary to deliver physical science and engineering courses allow for affordable development and delivery of multimedia course materials to be incorporated into distance education courses for home-based learners. For this project, we are currently using FirstClass™ as our CMC software package, which thus far has been suitably low-cost, easy to use, and reliable. To address the problem of adequate student computer competence, we inform students in their registration materials of the expected minimum level of competence; we also offer students additional support by providing written and on-line documentation, some limited hands-on training during student orientation, and alerting them to available but often overlooked resources for learning more basic computer skills, for example the on-line tutorial on basic computer navigation provided with Windows.

Designing for portability

Another principal project objective is to enable other institutions in the Virginia Community College System (VCCS) and elsewhere to adopt the degree program and its individual courses for offering to their students. Since ELI students are neither remote nor campus-based, courses may require 4-12 trips to a NOVA campus. However, courses are also being designed to allow VCCS and other interested institutions to replicate the course design model.

Developing physical science and engineering laboratory activities
Creating laboratory activities of acceptable quality for home-based learners in chemistry and physics courses for engineering and physical science majors is especially challenging. Designing laboratories for these courses requires substantial effort to think through how and what students need to learn -- what is essential for students to learn by hands-on experience, what kind of equipment and materials these experiences require, and what are effective alternatives for hands-on learning experiences. Fortunately, there are a number of effective strategies for designing laboratory activities for home-based learners without sacrificing quality.

On-campus labs -- Our chemistry faculty determined that half of their laboratory activities required on-campus access to laboratory equipment. Physics and chemistry courses reduce on-campus time required by structuring pre- and post-lab activities so that they can be done at home or on-line in collaboration with fellow students. Students in one engineering course will be able to access software available on the mainframe computer on-campus or purchase moderately priced software to use on their home computer.

Home labs -- Although development of home-based chemistry laboratory activities was severely proscribed by state regulations forbidding distribution of chemicals through the mail, physics laboratories rely in part on home lab kits that are sent to students upon enrollment. Selected chemistry laboratory exercises involving observation and measurement have been converted into paper-and-pencil exercises without sacrificing instructional quality.

Field trips to museums and other facilities -- Chemistry faculty designed two laboratory activities to be performed at a science exhibit at the Smithsonian Institution in Washington, D.C.; local museums and other educational facilities may have hands-on exhibits, programs, or other activities that are suitable learning experiences.

Video -- Chemistry students are required to view an American Chemical Society-produced video on lab safety and pass a quiz on its contents before participating in an on-campus lab. Physics courses rely in part on videotaped laboratory experiments, while elaborate laboratory science demonstrations available on commercial videodisc can save chemistry faculty considerable setup time and expense while offering equal or better quality. The engineering graphics course utilizes video to demonstrate how to perform operations in software programs such as AutoCAD.

Computer simulations -- The Electronic Lab Simulator (ELS) developed by Vanderbilt University [Bourne, 1995; Brodersen, 1995] is currently being used in a NOVA electrical engineering course on-campus and will be incorporated into ELI courses. While such 'virtual lab' programs do not offer direct hands-on experience, they do offer numerous advantages such as low setup time, cost and maintenance, infinite replicability and patience, and often a wide variety of test cases. As a result, such programs are often equal and even superior to laboratory experiences.

Transmitting graphical content

Engineering courses at NOVA require use of computer- and graphics-intensive applications such as AutoCAD and FORTRAN, so transmitting large graphics files electronically is an important design issue. Composing and transmitting equations and formulas electronically is also still notoriously difficult, especially with technology available to home-based learners. More powerful software products such as Mathematica or Maple V are too expensive and otherwise unsuitable for our use, so we are using more affordable commercially available applications to enable graphical content transmission. FirstClass readily enables users to attach graphics files to text documents, which can be accessed by recipients with the related application at their workstation; FirstClass also has limited capabilities to send graphics messages directly. To enable faculty, students, and tutors to compose and send documents to each other containing equations, formulas, and text, ELI is currently experimenting with a procedure combining the use of FirstClass and Expressionist™, an equation typesetter product. Expressionist features a WYSIWYG interface that enables users to compose equations and formulas relatively easily by pointing and clicking from a palette of common symbols and characters, a process that can be described as 'electronic scrabble'. While still not as easy as drawing equations or symbols freehand, it reduces a normally laborious task to a manageable one with a relatively modest learning curve, and so far appears to be suitable for our instructional purposes.
Representing scientific processes instructionally

While providing a means to transmit equations, formulas, drawings, and other graphical content is important, supporting demonstration of processes such as how to create a drawing or how to arrive at a correct solution is even more important for effective instruction. Video is an obvious choice for demonstrating these processes, and as noted above we are using video to demonstrate how to perform AutoCAD operations. However, we are also trying to find affordable ways to represent scientific processes instructionally via computer networks. Whiteboard and other videoconferencing technologies are not yet sufficiently cheap and widely available for us to use with home-based learners, so we are currently experimenting with using screen activity recorders such as Lotus ScreenCam™ to record process sequences, for example in creating FORTRAN programs and to train students and faculty how to use the applications being provided (i.e., FirstClass and Expressionist). Screen activity recorders typically allow recording of computer screen activity with explanatory captions (a soundtrack can also be recorded with some products, a feature not available to us since most of our students do not have sound cards in their computers). Screen activity recorders can thus be a relatively inexpensive way of creating multimedia course materials.

Developing faculty

Teaching home-based learners through asynchronous collaborative learning has required participating faculty to develop skills in a number of areas including:

- collaboration: knowledge of collaborative learning activities and skills in asynchronous learning design
- computer conferencing: general computer skills, competence with specific software and peripherals, and specific skills in conducting computer-mediated communication (CMC).
- distance education: general skills such as advance organization of course design and delivery
- ELI course delivery: effective instruction within ELI's course delivery structure
- video production: content organization and preparation, and on-camera delivery skills.

Although project faculty initially had some of the requisite skills and experience, substantial additional development was required in the project's first phase [Fig. 1]. Faculty development has proceeded in stages to allow faculty to become competent in more basic areas such as course design, video production, use, while becoming familiar with the possibilities of interaction and collaboration [Fig. 2]. As course development has continued, faculty have become more competent in these areas, enabling them to integrate asynchronous interaction and collaboration into their course activities [Fig. 3].
Current Project Status

Currently, five courses in engineering, mathematics, chemistry and physics are being offered; five courses are under development or revision, to be offered during the Fall Semester of 1996. The remaining four courses will be developed during the fall semester to be offered the following semester, so that the entire degree program will be available starting in the Spring Semester of 1997.

Acknowledgements

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SWAN: A Student-Controllable
Data Structure Visualization System

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Abstract: Swan is a data structure visualization system. Its main purpose is to allow the user to visualize the data structures and the basic execution process of a C/C++ program. Swan views a data structure as a graph or a collection of graphs. By “graph,” we include both general directed and undirected graphs and special cases such as trees, lists and arrays. As a part of Virginia Tech’s NSF Educational Infrastructure Grant, Swan will be used in two ways: by instructors as a teaching tool for data structures and algorithms, and by students to animate their own programs and to understand how and why their programs do or do not work.

1 Introduction

Students in Computer Science are constantly asked to understand dynamic processes in the form of computer algorithms. Aside from a pseudocode or computer program implementation, a higher order description for the algorithm is usually conveyed in words, perhaps with a well-chosen picture or two. Unfortunately, computer code, words and individual pictures present only static descriptions, specific views or instances of a dynamic process. Perhaps the reason why some otherwise good students have trouble understanding code examples is that they are unable to translate such static descriptions to a dynamic process in their imagination.

Many of the algorithms studied in undergraduate computer science courses operate on fundamental data structures such as lists, trees and graphs. Thus, a natural visual component to the workings of many algorithms is the series of changes that take place to the corresponding data structure. A well organized presentation of these changes in the form of a graphical visualization can help to bridge the “concept gap” encountered by many students when studying algorithms.

In recent years there has been much interest in algorithm animation and data structure visualization systems (generically referred to below as program visualization systems). In general, the goal of such systems is to provide visualizations of the dynamic processes embodied in computer algorithms. Several successful program visualization systems exist, see [Roman & Cox 1993, Tamassia & Tollis 1994] for examples. Program visualization systems have been used for teaching, presentation, and debugging purposes.

This paper describes the use of Swan, a data structure visualization system, as an aid to computer science education. Swan allows users to visualize data structures and the basic execution process of a C or C++ program. Swan views a data structure as a graph or a collection of graphs. In Swan, a graph may be either a general directed or undirected graph, and may be restricted to special cases such as trees, lists and arrays.

As a part of Virginia Tech’s NSF Educational Infrastructure Grant, Swan will be used in two ways: by instructors as a teaching tool for data structures and algorithms, and by students to animate their own programs and to understand how and why their programs do or do not work. This paper describes the design features of Swan that make it particularly useful as an instructional aid.

A program visualization is the result of interactions among three participants: the programmer who develops the original program, the animator who defines and constructs the mapping, and the viewer who observes the graphical representation. Swan visualizations start with a program that implements some data structure to be visualized. The annotator (who may be, but need not be, the original programmer) adds calls to the Swan Annotation Interface Library (SAIL), resulting in an annotated program. This program is compiled, and the viewer runs the resulting executable, which provides the functions of the original program plus a Swan visualization of the selected data structures.
The main design goal for Swan was to create an easy-to-use annotation library combined with a simple, yet powerful, user interface for the resulting visualization. Several features distinguish Swan from most other program visualization systems:

1. Swan provides a compact annotation interface library. Fewer than 20 library functions are frequently used.
2. The viewer’s user interface is simple, straightforward and uniform.
3. The annotator decides the semantics of the views, i.e., with which variables the graphical elements in the views are associated, and also controls the progress of the annotated program in a straightforward way.
4. Swan provides automatic layout of a graph so the annotator need only concentrate on its logical structure.
5. Swan allows the viewer to modify the data structure.
6. Swan was built on the GeoSim Interface Library [Hines, et al. 1994], a user interface library developed at Virginia Tech that allows Swan to be easily ported to X Windows, MS-DOS and Macintosh computers. It is crucial for educational software to run on the variety of operating systems that are widely used in computer science classes.

Currently, two versions of Swan have been developed: one for UNIX systems with the X Window system installed and one for MS-DOS. Information about Swan can be obtained through the World Wide Web at URL http://geosim.cs.vt.edu/Swan/Swan.html.

Visualization can be applied either to the physical implementation for data structures in a program or to the abstraction represented by the data structure. For example, two views of a graph can be provided as part of an annotated minimum spanning tree algorithm. In Figure 1, the view on the right is an adjacency list representation of a graph, a visualization of the physical implementation used by the annotated program. The view on the left shows the logical topology of the graph, an abstraction represented by the adjacency list. These two views of data structures coexist in Swan in a consistent form, since both are represented by Swan as graphs.

In the standard model for program visualization systems, program visualization is a one-way information passing process: The programmer first writes a program, the annotator then annotates the program, and finally the viewer can run the program to see the graphical views. In Swan, information can be passed from the annotator to the viewer in the form of a graphical representation for data structures. Information can also be passed from the viewer to the annotator via modification requests. Although this cannot be regarded as a complete two-way communication between the annotator and the viewer because of the unequal status of the two participants (i.e., the annotator has complete control of the views to be constructed while the viewer can only modify the program’s data structures under the restrictions imposed by the annotator), it provides a powerful mechanism to encourage...
the viewer to be more active in exploring the program and gaining new insights. This capability makes Swan different from most program visualization systems in which the viewer can only watch the animation passively. We believe it not only makes Swan more suitable as an instructional tool, but also shows the potential for Swan to be used as a graphical debugging tool at the abstract level.

2 The Swan System

Swan has three main components: the Swan Annotation Interface Library (SAIL), the Swan Kernel, and the Swan Viewer Interface (SVI). SAIL is the library used by the annotator to create visualizations. SVI allows a viewer to explore a Swan annotated program. The Swan Kernel is responsible for constructing, maintaining, and rendering all the views generated through SAIL library functions. It accepts viewer’s requests through SVI and takes appropriate actions, and is the intermediary through which an annotator communicates with a viewer.

Because Swan is a data structure visualization system designed to support algorithms in which graph-like objects are frequently referenced, it is natural that graphs are chosen as the basic elements in Swan. All views in Swan are composed of Swan graphs. A Swan graph has a set of nodes and edges. A graph is defined by the annotator via its nodes and edges. Graphs have default display attributes for their nodes and edges, which are used by Swan to render the corresponding graphical objects. Nodes and edges can have their own individual display attributes that override the graph’s default values.

The logical structure for a graph built by the annotated program is stored in the Swan Logical Layer. A standard adjacency list representation is used to store the graph’s nodes and edges. After appropriate layout algorithms are applied, a physical representation of the layout is kept in the Swan Physical Layer. Every Swan graph has physical attributes that affect its graphical display. The most important attribute is the position of the graph and the positions of all of the nodes and edges in this graph, that is, the layout of the graph. To decide these positions is to layout the graph. Several graph layout algorithms have been implemented in Swan to deal with different graphs types so that the annotator does not need to spend much time on layout himself.

The separation of a graph’s representation into logical and physical layers makes Swan adaptable to changes in its graphics display toolkit and also portable to other graphics platforms. Graph layout algorithms used in Swan only specify topology without concern for the many details of visual attributes of the graphs.

Events generated by SVI due to the interactions between the viewer and Swan are sent to the Swan Event Handler. A Swan annotated program runs as a single thread process. The events generated from SVI are stored in an event queue. Initially the annotated program has control of the process. Whenever a SAIL function is invoked, Swan will process all events in the event queue (e.g., button presses). At this point, the Swan Event Handler takes control. After the SAIL function completes, control is returned to the annotated program.

There are three basic states in Swan when it is active: Run, Step and Pause. The process may run continuously (i.e., in Run state) or step by step (i.e., in Step state). “Step” here refers to the execution of a code segment ending at the next breakpoint set by the annotator. Swan lets the annotator decide the size of the step because it is impossible for Swan to identify the interesting events in the annotated program.

The viewer interacts with an annotated program through the Swan Viewer Interface (SVI) as shown in Figure 1. The SVI main window contains a control panel and three child windows: the display window, the I/O window and the location window. The display window contains the graphs output by Swan. The I/O window is used by the annotator and the Swan system to display one-line messages and get input from the viewer. The coordinates of the current position of the cursor in the display window are shown in the location window.

The viewer can pick a node or an edge in the Swan display window to get more information about it. The viewer can pan and zoom over the graph view; can switch between Run and Step states; and can modify graphical attributes of a graph, such as default graphical attributes for its nodes and edges and its layout method. For a node, attributes include type, color, size and line thickness. For an edge, attributes include color and line thickness.

The viewer can interactively modify the logical structure of a Swan graph, specifically by inserting or deleting nodes or edges. The annotator can enable or disable any of these editing functions. If the annotator enables an editing function, he must provide the action that occurs in response to the selected function (i.e., the annotator must define what it means to insert a new node).

There are several algorithms implemented in Swan to lay out different kinds of graphs automatically. Linked lists and arrays (in both horizontal and vertical forms) are examples of Swan layout components. Layout compo-
nents allow an annotator to build a more complicated structure than the simple linked list or array. In Swan, a node in a layout component may be a parent node of another layout component. Therefore, a simple linked list can be recursively expanded to represent relatively complex structures. Swan also supports trees and general graphs as layout components.

3 Swan in the Classroom

A number of design features make Swan an ideal tool for creating program visualizations for educational use. The most important is ease of use. Throughout the project, our main goal was to create an annotation library that would be easy to use. Swan is not nearly so extensive as many other program visualization systems, and in particular Swan has no support for animation. However, most existing program visualization systems are quite difficult to learn, and require extensive programming to create visualizations. In contrast, a motivated instructor or student can learn most of Swan and program a complete visualization for a simple algorithm in an afternoon. Thus, Swan is a practical tool for use by instructors and students, rather than by visualization experts.

Just as important as ease of use for the annotator is ease of use for the viewer. Swan has a straightforward viewer interface. Once the program is invoked, the basic visualization requires only that the viewer press the “STEP” or “RUN” buttons. More sophisticated interface activities, such as making changes to a data structure, require only a handful of different actions by the viewer.

Swan’s approach to program visualization through program annotation makes it appropriate for classroom use, since existing algorithm descriptions can be annotated with only additions, not modification. This allows the instructor to easily add in a visualization for an algorithm that she already uses in an existing course. (This assumes that the original code example is in C or C++.) For example, if a particular implementation for inserting a value into a binary search tree is presented in a textbook, the instructor can annotate that precise algorithm, rather than create a variation suitable for visualization purposes.

Swan has the uncommon feature that the annotator can provide functions that allow the viewer to modify the data structure under study. This means that a student can actively use an existing Swan visualization to create his own examples. Again using the binary search tree as an example, the student can watch the effects of inserting various values into the tree, testing his own assumptions and hypotheses about the algorithm’s behavior.

Swan has a simple, built-in method for presenting commentary about the current state of an algorithm via the I/O window at the bottom of the screen. The annotator can present a brief text description for each step of the
Figure 3: Visualization of a Red-black tree.

algorithm as it happens. Thus, not only will the viewer see the changes to the data structure as they take place, but ongoing commentary as well.

Note that the speed of the visualization, and the commentary, are completely controlled by the viewer, who advances to the next step of the visualization by pressing the “STEP” button. This is an important feature in an instructional tool, allowing each student to absorb information at her own speed.

4 Experiences and Future Plans

We currently have developed a small number of visualizations for testing purposes. Three are illustrated in this paper. Figure 1 shows two views of a graph as part of a Minimal Spanning Tree algorithm. Figure 2 shows a Huffman coding tree. Figure 3 shows a Red-black tree.

To test the ease of use of the annotation system, a group of three graduate students volunteered to work with the system. None had prior experience with Swan. Each was asked to provide an annotation for the Heapsort algorithm. The original C source code for the algorithm was provided to the subjects, and they were allowed to create a visualization in any way they desired.

Our testing showed that the Swan annotation system can be learned and the first simple visualization produced in an afternoon. Each of the subjects successfully produced visualizations of Heapsort. However, we also observed that producing good visualizations requires a degree of creativity. Just as creating a good lecture or a good homework exercise is difficult (even when the physical activity required is made easy by a document processor), it is difficult to create a good program visualization.

In Spring, 1996, Swan visualizations are being incorporated into homework assignments in our senior algorithms course. The current plan is to use Swan visualizations to review and extend the class discussion of the following algorithms:

- Red-black trees;
- Huffman codes;
- Topological sort;
- Network flow (Ford-Fulkerson method);
- String matching; and
- Approximating vertex cover.
- A visualization of the lower-bounds proof for finding a minimum and a maximum element from a list.
These algorithms represent a diverse selection that can benefit from Swan’s graph visualization capabilities. The vertex cover visualization will be programmed and annotated by the students themselves.

At the beginning of the Spring Semester, 1996, a new graduate research assistant who had no prior experience with Swan was assigned to create the visualization listed above. As of this writing, he has created three visualizations. His first experience with Swan was the visualization for the Min/Max element lower bounds proof. This required about 4-6 hours to implement. The second visualization was for the Red-black tree, and required about four hours to implement the visualization (this does not count the time spent implementing the Red-black tree algorithms themselves). The third visualization was for the Huffman coding tree. The basic tree construction visualization took about three hours to implement, with another two hours required to illustrate the message encoding/decoding process.

Note that the three visualizations described above were created for instructional purposes. The implementor reported that about 2/3 of his time was spent setting appropriate pause points in the algorithm, and devising the tutorial messages that go along with the visualization. If he had been using Swan only to gain an understanding of the code (for example, to help in debugging), much less effort would have been required.

The Red-black tree and Huffman coding tree visualizations have been used to solidify students’ understanding of the algorithms developed in class and in the text. Students retrieve the visualizations from the class Web site and run them on their own computers. The visualizations allow students to create and experiment with trees that are significantly larger than can be created by hand, without the effort of implementing the algorithms themselves. As a consequence, the assignments are more elaborate than were previously possible. The assignments also benefit from a common graphical interface in all the visualizations. Students have reported only two small problems with actually using the visualizations. In all cases, they were able to accomplish the assigned Swan tasks without any training in the Swan interface itself.

We also expect to produce a series of visualizations in the coming year for our sophomore level data structures class. These visualizations will include illustrations of several standard sorting algorithms; fundamental list, stack and queue operations; and a more complete binary search tree visualization.

There are a few extensions that we plan to add to Swan to enhance its educational value. The first is to extend the size of the comment window at the bottom of the screen. Presently, only one line of text can be visible at any time. This should be enlarged. The other necessary feature is a window showing the program’s source code. Some program visualization systems are quite sophisticated in that they automatically associate visualization views with source code. Our plans are much simpler. Essentially, we will allow the annotator to provide an ASCII pseudocode source. A SAIL function will be added to indicate the current line in the source that should be marked during execution of the actual program. Thus, the annotator will have complete control and responsibility for matching the source code window to the current program view, controlled by an easy to use library function.

5 References


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Creating Educational Guided Paths over the World-Wide Web

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Abstract: The extensive and encyclopedic materials found on the World-Wide Web must be tailored and contextualized to support the instructional goals of education. We have applied the concept of a guided path, an ordered list of pages independent of the existing Web structure, and have implemented a prototype (Walden’s Paths). Besides creating the structure, a teacher may annotate the individual pages of a path to provide transition, emphasis, and missing explanation. In addition, some limited interactivity and control over the display of remote information is possible in our prototype. Walden’s Paths works with existing Web browsers and servers allowing its integration into an educational setting with existing hardware and software.

1 Introduction

Students develop knowledge-building skills and strategies through exposure to an expanded discourse community and broad base of information resources [SB93]. The Internet shows promise of providing such exposure: a wealth of new material and a spectrum of new voices are becoming available to students and educators alike through networked electronic information resources like the Internet’s World-Wide Web. The breadth of this material promises to increase as digital library efforts continue and research organizations recognize the importance of contributing to globally accessible multimedia databases.

As extensive and encyclopedic as these materials are and promise to become, they still must be tailored for classroom use. The bulk of the material available today is not aimed at the needs of K–12 students, although many elements—image collections, simulations, digital video segments, audio, electronic versions of well-known works of fiction and reference materials, library indices, databases, and hypertextual documents—have the potential to play a strong supporting role in the curriculum of tomorrow.

Access to extensive resources and a broader discourse community will be instrumental in supporting learning through exploration (a natural complement to what Pea and Gomez refer to as learning-in-doing [PG92, Pea93]). Exploration is a valuable mode of learning, but it is even more valuable when it is constrained by a curriculum developer’s well-conceived ideas of which materials should be included, supplemental text aimed at the particular level of student, and additional structure and ordering to help the student comprehend what he or she is discovering.

Scardamalia and Bereiter distinguish between knowledge reproduction strategies and knowledge building strategies: knowledge building strategies focus on the development of understanding, while knowledge reproduction strategies focus, very literally, on students’ abilities to absorb passively, then recreate, what they have been told [SB93]. Our focus is on using guided exploration of large scale information resources to engage students in comprehending, interpreting, and evaluating materials—the substance of knowledge building and critical thinking.

The World-Wide Web (the “Web”) and its hypertextual paradigm are well-suited to form a basis for exploratory learning. A central theme of hypertext and the Web is traversal: a reader moves from one segment of material (a node or page) to another by following a link to related material. A reader’s need for detail, explanation, alternative discussion, or related topics is guided by their own desire to explore, to construct knowledge, to find information. Of course, without a particular aim in mind, or any sort of guiding purpose or instruction, link following easily can become a random walk. It is necessary to add meta-structure (that reflects an instructor’s curricular goals) to the underlying hypertextual network to make it suitable for exploratory learning and knowledge construction.

We can envision the future to some extent by looking at materials, media, and genres available on the Internet today. If we look, for example, at the NASA Spacelink Web site1, we can find information for the public about NASA programs (including existing educational materials). Or we can find movies of insects on Iowa State’s entomology information server2. Or we can view the Library of Congress’s Soviet Archives Exhibit3. Some of the

1http://spacelink.msfc.nasa.gov/
2http://www.public.iastate.edu/entomology/ImageGallery.html
3http://www.ncsa.uiuc.edu/SDG/Experimental/soviet.exhibit/entrance.html
information provides methods for interaction; for example, Xerox PARC’s map viewer\textsuperscript{4} allows readers to zoom on map regions or search for place names as one would in a gazetteer. Simulations and visualizations are also available through the Web to help readers grasp more difficult materials and concepts. Authors have created a number of indices to effect additional structure on top of these diverse sites, but most of them are just lists of Web pages or Web server sites or hierarchies of such lists; few of them provide the additional rhetorical structure that one would encounter in materials for classroom use.

2 Problems of General Web Access

What are the specific kinds of problems that we anticipate (and have observed) when students are given general access to the kind of large, heterogeneous collections of information that we find on the Internet? Basic needs for adapting and tailoring the Web for exploratory learning include mechanisms: for defining a territory or information space; for adding structure to the information space to promote comprehension and accessibility of the material; for tailoring existing content and links to meet curricular constraints; for tracking student progress and adapting paths to individual differences; for maintaining the quality and integrity of the derived instructional materials; and finally for sharing these metastructures and instructional strategies within a community of educators.

A significant amount of material is not organized for comprehension by a K–12 student. Much of the information on the Web assumes access by an information-seeking adult or possibly an adult who is casually browsing or “reading around.” This material, if left as is, will bore or frustrate most students, since they require a more structured presentation of background material on the way to exploring less organized information.

Given a relevant territory (which we will refer to as an information space) and a general organization for material, a problem still remains: the material—the content and links—still needs to be tailored to address the needs of school-age learners. Because the Web’s hypertextual structure is represented by content mark-up [BL94] (i.e., links are denoted within the pages themselves), this sort of tailoring requires methods for changing material at a within-page (intra-node) level. For example, a given Web page may include too many links (and possibly links to material outside the information space). Or a Web page may need additional rhetorical structure to guide the student; because many Web document genres (such as home pages) are new, many authors who contribute valuable material are inexperienced in constructing readable hypertexts. Within-page tailoring may also be necessary to adapt material that is presented at the wrong level for a K–12 student. A second grader who is interested in the space program will not be able to understand a mathematical description of vehicle trajectory, but may be able to understand diagrams or a simple verbal account of the same material.

3 Approach

The initial metaphor in implementing an environment to support focused network exploration is a generalization of the \textit{guided path} [Zel87, Zel88, Tri88, Zel89]. As originally defined, the guided path provided the means for directing a reader’s traversal along a path of components extracted from a set of documents. The ordering of components on the path is not constrained by that of the source documents—in other words, the components encountered do not have to follow the temporal orderings of the source. In essence, the guided path allows creation of a \textit{presentation}, defining a meta-structure that is layered on top of the underlying documents’ preexisting structures.

The guided path is well-suited for control of presentations and for communication of relationships. It serves as a meta-structuring mechanism that can be used to express an order over a large collection of information. Besides providing an ordering of pages, a guided path can provide additional context for the page through annotation. By providing text or other annotations in addition to the content of the page, the path author may provide a rhetorical structure to the path as a whole, create transitions to fill in informational gaps between pages, and emphasize particular aspects of the materials.

3.1 Prototype Path Server

To take advantage of the variety of information and software that makes up the Web, a guided path mechanism must work with the common Web browsers and Web servers. We adopted a strategy to create a “path server” to operate between a student’s browser and the information server, as shown in Figure 1. The path server stores information

\textsuperscript{4}http://pubweb.parc.xerox.com/map
specific to the path—the order of pages in the path, annotations, and the URL for the original information. Our prototype path server, called Walden’s Paths, limits paths to be linear; no “side trips” or “alternate routes” can be specified by the path author. Enhancements are a topic of current investigation. In related work Nicol, et al., also have investigated application of paths to the Web with their Footsteps mechanism [NSS95].

Upon execution, our path server distinguishes between three basic situations: when a student is accessing the path server but not a specific path, when a student is accessing a particular page in a path, and when a student is accessing a page not on the path. The path server identifies the correct situation by examining an environment variable called the URL query string.

If the student is not currently viewing a path, the path server lists the possible paths that the student can choose from. This is shown in Figure 2—left. The list is built using an index, which is stored with the path server.

If the student already is viewing a path page, the path server determines the appropriate URL to retrieve using the path information stored at the server. After determining which URL is requested, the path server performs two tasks. The first task is to retrieve the Web page of the URL. Once the page has been retrieved, the path server adds path controls and annotation to that page. There are four elements of the path controls: forward and back arrows to permit traversal of the path, a Walden’s Path logo that, when selected, returns the student to Figure 2—left’s display, and a row of numbers that both situate the student within the path and also permit direct access to locations on the path. Annotations, added to the page just below the path controls, can include plain text and HTML markup, including anchors, forms, and image sources. The path server then sends the resulting path page to the student’s Web browser, such as Netscape or Mosaic, which renders the modified HTML markup. Figure 2—right shows a page in a path on ancient Macedonia and Alexander the Great.

If the student chooses to follow a link that is not part of the authored path, the path server retrieves the requested Web page and prepends a Walden’s Paths Logo that, when selected, provides a link back to the last path page seen by the student. Figure 3—left shows a page off of one of the authored paths. In order to implement this the server must make sure all the student’s accesses go through the path server so the “back to path” controls can be
added. To do this, the path server replaces all the URLs specified in HTML anchors to route requests through itself. One problem in implementing our prototype has been that many URLs are context-dependent, or "minimized". Minimized URLs must be expanded by the path server for this to work correctly.

3.2 Speeding up Path Access: Caching at the Path Server

There are possible limitations of network bandwidth and accessibility that need to be addressed for the use of the path server in educational settings. First, not all schools have network connections, much less fast network connections. By caching Web information when it is accessed, the path server can reduce the required network traffic between the school and the Internet. Additionally, as sites on the Internet are not always accessible, pre-caching pages that are part of a path allows a teacher to know that the information on the main path will be available in the classroom.

To support these goals of reducing the reliance on network bandwidth and guaranteeing the availability of information, we have been investigating two methods of caching documents at the path server. The first method, regular-caching, is like the caching done by Netscape and some other browsers. The path-server simply caches documents as they are retrieved from the Internet. This approach saves what the students are browsing, including Web pages not on the main path. The advantage of having the path server do this caching over having the Web browser cache information is that the cache is shared by all students of the path server. This means each page is only retrieved once (and stored once) for everyone using the path server.

The second method of caching, pre-caching, means the path-server caches what it may need later. Normally a document is not retrieved (and thus not cached) until a student requests it. Here, we can take advantage of the fact that we know beforehand the URLs that are going to be accessed during a session with the path server. In the case of guided paths, it is natural to assume that the pages on the path are likely to be viewed later, especially if a student has begun traversing that path.

As with Web browser caches any choice of caching strategy inevitably leads to issues concerning versioning, cache size, and cache time-out policies. In some cases there is no clear solution—different use environments favor incompatible caching policies. Cache management remains an area of active investigation in our project.

4 Authoring Paths: Experiences and Issues

Figure 2—left showed the path server’s introductory page, listing a number of our experimental paths. Authoring these paths has augmented the lessons reported in our previous accounts of path construction [MI89], especially since much previous work on paths has relied on locally-controlled document collections. By contrast, we have
used materials gathered from the Web as a basis for our paths. In our examples, existing Web pages from different servers around the world are structured as simple linear paths, and supplemented and explained by the authors’ narrative, implemented as a prepended annotation. Example paths include an artifact-centered description of Ancient Macedonia and Alexander the Great, a short account of the people and events of the Cuban Missile Crisis, and a narrative explaining our Center’s digital library work.

Our experiences highlight a set of issues and questions that will guide future development. We focus on four: (1) the interaction between available content and curricular goals; (2) author control of Web page markup to promote consistent styles and coherence within a particular path; (3) the potential for interactivity in our prototype; and (4) supporting and accelerating the path authoring process.

How does existing content interact with instructional goals? The Web is a rich source of content, but is it the content that an instructor needs to put together a lesson on the topic of choice? Will the availability of materials tend to drive the kinds of paths teachers create? Several of the example paths use sets of materials culled from different sites around the Web. It comes as no surprise that it is easier to construct an interesting path from an already coherent source (like a library of related images drawn from one or two Web sites) than it is to gather materials from many sites and integrate them. Text, as one would expect, is very difficult to reuse; it is frequently directed at a general Web audience, at a special interest group, or at an academic audience. Textual indices are slightly easier to reuse, but still must be adapted for instructional purposes (i.e., not all the links that they provide are appropriate). Images, sounds, and digital video clips are much easier to adapt for different uses. For example, Figure 3–right shows a page from the Cuban Missile Crisis tour. Note that while the image fits the path author’s intent, the Web page the author has selected has inappropriate text (which has been rendered in a very small font to de-emphasize it). In general, this characteristic of Web materials is leading us to look at ways of reusing document components (such as embedded images) rather than entire document pages.

What cues might a path author use to indicate path coherence? Most of these cues involve the introduction of additional markup in the path. For example, in our Cuban Missile Crisis path, the author has used a new font size to set off her annotations from the text of existing Web pages. It is easy to see how such markup—for example, markup designating a uniform background color, or using consistent image centering strategy—can promote a sense of coherence for the student. Many of our example paths introduce new markup elements to give the outside author's annotations a particular “look”. Our mechanism for indicating whether a reader is on or off an authored path (see Figure 3–left in the previous section) is yet another means by which coherence is supported.

Promoting interactivity is an important goal of our project. When paths are simple, it is all too easy for a student to fall into passivity—just clicking his or her way from beginning to end, not exploring or constructing any new meaning. There are many ways around this apparent pitfall. The first, and most decidedly technological solution, is to provide authors with a more expressive path mechanism, one that promotes more active exploration. Our past work [MI89] has found that paths generally have “spines” and “side trips”; side trips are interesting digressions that allow a reader to pursue material in more depth. Other of our past work [SF89, FS94] provides a general mechanism for expressing paths through documents and their components. But we have seen exploration facilitated by simply adding links into the annotative text, and inviting the student to jump off the beaten path for awhile. The previous section discusses how the path server provides “off the path” feedback, and a mechanism to return. We are also considering ways to limit off-path exploration, so that an interesting digression doesn’t become a distraction, or a foray into material well outside the classroom curriculum.

Of course, interactivity means more than additional places to click. Figure 3–right shows how HTML forms markup has been used to invite student input; this markup, or “mailto:” links will enable a teacher to gather student reflections or responses to questions posed in the annotations. Other mechanisms have been developed for more traditional CAI-types of instruction, like system-evaluated multiple choice questions. We can also envision students authoring paths themselves (either for their peers, for their teacher, or for younger students) as a more interactive form of engagement with the material.

How can we support the path authoring process? First, instructional design templates can make creating paths easier [JJR89, CG91]. At the least, most of our examples have an introductory page that sets the tone and style for the rest of the path. In an ideal world, instructional designers and experienced path authors can create general types of paths to help newer path authors—teachers and students—satisfy their own instructional goals. Second, path cues—like the progress along the path that is shown at the top of the constructed page in Figure 3–right, “Page 8 of 12 in this path”—help the author by making certain common kinds of reader feedback available across all paths. Finally, we can support the reuse of portions of paths, including individual annotated pages. A discussion of John F. Kennedy from the Cuban Missile Crisis path might fit well into a unit on American Presidents.
Our initial prototype, and our experiences authoring paths in it, provides a promising artifact that provides the basis for interaction with classroom teachers and students. Our next step is to involve teachers and students in the project; using this interaction, we will continue to refine and develop the path authoring and path server capabilities.

5 Conclusions

In this paper we have discussed the use of guided paths to overcome some of the difficulties associated with using information available via the network in an educational setting. We have described our path server, Walden’s Paths, which allows the contextualization, annotation, and ordering of Web pages to provide paths on particular topics. The paths provide for a rhetorical structure independent of the materials existing structure.

The path server is independent from specific Web browsers and servers, enabling its use with the expanding variety of such software. This architecture also allows the information to remain at its original Web location or to be cached locally to improve access time and guarantee availability. There are a number of trade-offs in the caching of networked information that we have begun to investigate in the context of curricular use.

Through building a set of sample paths we have begun to gain experience with the issues of path authoring. Our initial prototype enables the path author to provide some limited interactivity and control over the display of remote information. This will be extended as we build tools to support the authoring of paths.

Acknowledgments

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References


Analysis of Hypermedia Browsing Processes in Order to Reduce Disorientation

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Abstract: Difficulties with orientation are common in hyperdocuments. This paper describes an exploratory study to research the role of a navigation map, as help tool, during browsing processes. We try to establish the influence of this navigational tool, provided by a hypermedia prototype, in retrieval tasks. Twenty-two students tested this prototype and some data were collected: scores obtained in a task-test and a record of the path followed by the subjects. With these data we define a set of ratios as an attempt to understand the subjects' browsing processes. Findings suggest that the map was not effective in the ameliorative role. Perhaps it is not wise to assume that a map that helps performance in a spatial context also form an aid to a hypermedia environment.

Introduction

Hypermedia environments are complex systems based in the non linear organisation of the information. This conceptual assumption introduces new problems as the design of the hypertext structure, the organisation of the content supported by the hypertext structure and the navigation in the system. Our present concern is addressed to browsing/navigation process, a major problem in hypermedia systems, that results from the explosive ability of the system to develop complex networks of information, with direct implications in the user interaction process as the disorientation. Identified as being lost in hyperspace [Edwards & Hardman, 1989], this is the main concern to the present study: how and what tools should be used to manage the system; how users deal with reference tools, as maps. We assume that these information systems are quite different from the textual ones, and the mental representation from the information system should be another than the one from the sequential process that has reached us from the printing techniques. Even when the expert reader of a printing text uses a non sequential process he has a static reference, from the book, the page, the paragraph, the word and the graphic layout of the textual interface. In a hypertext environment this reference is dynamic and probably the user will need to deal with a virtual reference model.

Problems associated with the navigation suggest controversial approaches: the spatial and the conceptual [Stanton et al., 1992]. Generally, hypertext systems are conceived as spatial ones, these are central conceptions of the interface metaphor development and the browsing tools, as maps. [Edwards & Hardman, 1989] suggest that the representation provided by navigational tools should be similar to the representation formed by the users, and the same authors identify three distinct situations when the users feel lost: i) not knowing where to go next; ii) knowing where to go but not knowing how to get there; and iii) not knowing the current position relative to the overall hypermedia structure.

The analogy between navigation in physical environments and information ones was proposed also by [Canter, Rivers & Storrs, 1985] that stress the analogy of the psychological processes involved in both domains. Thus, users should develop a spatial cognitive representation from the information environment. However
[Stanton et al., 1992:432] suggest that a cognitive map "indicates that there is some long-term semantic memory representation of the environment, but that is more like a network map than a survey map…” and stress the interaction between a cognitive map formation under the spatial map reference.

As a result of user's behaviour in high complex hypermedia environments, the designs of these systems have been object of particular development and several approaches, to help users to avoid disorientation problems while browsing hypermedia systems. The establishment of conventions, as metaphors, and the design of browsing tools, as maps, is some of them [Kim & Hirtle, 1995]. Conceived as spatial metaphors of the information network, as the metaphors of the real world are to the interface design [Mountford, 1995], spatial maps could be cognitive aids to improve the cognitive mapping of the hypertext structure and reduce users' disorientation.

Our study examines specially the last situation related to navigational aids, and analyse a particular tool: a navigation map. [Nielsen, 1990] argues that the use of the tourist metaphor tries to provide some of the same assistance to hypermedia users as that one that is given to the tourists. According to this, we would expect that navigation maps give the user an overview of the content organisation that will be appropriate to the navigation during the learning process in a hypermedia environment.

Method and procedure

For the present study we develop a hypermedia prototype concerning the theory of tectonic Plates (a global theory of Geology) that was used with a group of 22 high schools students randomly selected. The hypertext structure to organise the information in the prototype was the web model proposed by [Brockmann, Horton & Brock, 1989]. This particular model of organisation is potentially confusing and unpredictable as is suggested by the same authors, and that was assumed as a condition to the empirical study.

Information was presented in nodes-pages and the users can have access to several tools from any screen page by clicking on icons, as a notecard to individual comments, animation and, in a high level of the interaction, the navigation tools. In this prototype the aim was on a specific tool: the navigation map. This is a content index with the representation of the path followed by the student and the stages remaining. With the map we provide a global overview of the network but we exempted the representation of the multiple links among screen pages because it tends to be space intensive and consuming.

From the tool map the student could have access to any wanted screen page. The research design also includes a task-test to gather data from the instructional session with the hypermedia prototype, that was organised in 12 task-questions that students should answer during the work session.

Its goal was to lead students to search for requested information and write it down. Each task presented would imply that students were able to find the right pathway, into the hypermedia network, to get the information requested. The task given had the role of a stimulus to activate the users information-seeking process. To accomplish the task students should develop an oriented browsing style based or not in the map tool.

When testing the prototype we intend to explore the relationships between student's performance in searching information in a non linear database and the use of the navigation map presented by the prototype. This research includes two different moments: a drill and practice session with a special prototype made for it, and a major session with the application described above. During the first session (that we designate as short session) participants get familiar with the hypermedia environment and receive a brief explanation of the researchers purposes. During the second session students had a maximum of 45 minutes (time of regular class) for participating in the study. They worked through the hypermedia prototype at an individual computer. Necessary instructions were given in the begin of the session concerning the main aspects of the prototype interface and about the aims of the task-test.

The prototype includes a general function of identification of the user that generates a permanent file of each student's use of it. This program records the path followed by each student during the session time with the hypermedia application. The data recorded includes:
- code, sex, age and frequency of computers use of each student;
- name of the visited page;
- the objects clicked in each page that were important to solve the test;
- time spent in each page (seconds);
- frequency of visit to each page.

Data Analysis
The data analysis was based in the score obtained in the task-test, the time spent in each page visited, the frequency of visit to each information node and to the frequency of visit and time spending in the navigation map. Students could obtain a score in the task-test ranging from 0 (any question was correct) to 100 (all questions was correct). The remaining data were gathered in a traversal path record that took the form of a list of nodes selected by the student. Each student traversal path list could be compared to an ideal path, predefined by the authors, that referred only to important information nodes to the task-test. In order to deal with this data, we use ratios, that we intend as a measurement to the student behaviour, in the information network, oriented by specific parameters: searching, orientation, access and time.

Ratios used in present study were developed by the authors for the web model followed in the hyperdocument and adapted from previous research in the domain [Marchionini & Shneiderman, 1988; Stanton, Taylor & Tweedie, 1992; Gillingham, 1993; Canter, Rivers & Storrs, 1985].

In order to identify users performance in the experimental hypermedia application we define the following ratios: Search, (RSe) Orientation (ROr), Access (RAc) and Time (RTi). A brief description of these are: $RSe = \frac{n^e}{n^t}$ of nodes of the predefined path visited / total nº of nodes of the predefined path; $ROr = \frac{n^e}{n^v}$ of nodes of the predefined path visited / total nº of nodes visited; $RAc = \frac{n^e}{n^v}$ of nodes of the predefined path / ( nº of the nodes of the predefined path + nº of unnecessary nodes accessed); $RTi = \frac{time spent in nodes from the predefined path}{total time spent in nodes of the web}$.

Statistical comparisons were made to analyse data from the users’ browsing processes in the hyperdocument. Nonparametrics statistics with the Kruskal-Wallis test (n < 30), were made in order to analyse the significance of the frequency of the visit and time spent in the map with estimated ratios and results from the task-test for the 3 groups of performance identified.

Results

Data obtained from the task-test shows a medium result of resolution for the subjects, based in the modal score that was 50, with a mean score of 57.7 (SD = 18.1). Analysing individual performance for the task-test, we identify that 5 / 22 subjects (23%) had a score below 50 and 17 / 22 subjects (77%) had a score above or equal to 50.

From the analyses of the frequency of visit to the map tool in the hyperdocument we identify, among the subjects, three modes of use. The first group has 10 / 22 subjects (45%) that visited the map very rarely (below or equal to five times) during the session; the second group with 5 /22 subjects (23%) visited the map less rarely (between six and ten times) during the session; and the third group with 7 / 22 subjects (32%) visited the map tool more often (above or equal to eleven times)[see table 1].

<table>
<thead>
<tr>
<th>% of subjects</th>
<th>nº of visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>² 5</td>
</tr>
<tr>
<td>23</td>
<td>6 to 10</td>
</tr>
<tr>
<td>32</td>
<td>³ 11</td>
</tr>
</tbody>
</table>

Table 1: Frequency of visit to the map tool.

Time spent by the subjects in the map tool leads us to identify again three groups of performance during the session. From the data, the first group has 9 / 22 subjects (41%) that spent a short time (below or equal to 100 seconds); the second group has 7 / 22 subjects (32%) that spent a moderate time (among 101 and 250 seconds); and the third group with 6 / 22 subjects (27%) spent a longer time (above or equal to 251 seconds) [see table 2].

<table>
<thead>
<tr>
<th>% of subjects</th>
<th>time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>² 100</td>
</tr>
<tr>
<td>32</td>
<td>101 to 250</td>
</tr>
<tr>
<td>27</td>
<td>³ 251</td>
</tr>
</tbody>
</table>

Table 2: Time of visit to the map tool.

Correlation analysis between data variables were done. Only the more relevant results will be reported here.

Using Pearson correlation coefficient between data variables: frequency of visit to the map, time spent in the map, ratios of orientation, access, search and time, and task-test we had the following results [see table 3].
<p>| | | |</p>
<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Frequency of visit to the map</td>
<td>vs.</td>
<td>Ratio of Orientation</td>
</tr>
<tr>
<td>Frequency of visit to the map</td>
<td>vs.</td>
<td>Ratio of Access</td>
</tr>
<tr>
<td>Frequency of visit to the map</td>
<td>vs.</td>
<td>Time spent in the map</td>
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<tr>
<td>Time spent in the map</td>
<td>vs.</td>
<td>Ratio of Orientation</td>
</tr>
<tr>
<td>Time spent in the map</td>
<td>vs.</td>
<td>Ratio of Access</td>
</tr>
<tr>
<td>Ratio of Access</td>
<td>vs.</td>
<td>Ratio of Orientation</td>
</tr>
<tr>
<td>Ratio of Time</td>
<td>vs.</td>
<td>Task-test</td>
</tr>
</tbody>
</table>

Table 3: Variables correlation

Analysis of statistical significance for the three groups identified concerning frequency of visit to the map and the ratios in addition to task-test score show significative differences to the ratio of Orientation 0.007, and to the ratio of Access 0.003, with p < 0.05. We found also a value of 0.062 to the variable task-test, with p < 0.05. Although not significant the present value could be interpreted as a weak relation between the frequency of map visiting and the score obtained in the task-test. To the time spent in the map for the three groups identified there is a significative difference to the variables' ratio of Orientation 0.033, and ratio of Access 0.007, with p < 0.05.

Conclusions

Results do not show a significant difference in the performance of the groups related to frequency to the map with the Search ratio. This ratio indicates clearly the necessary effort to follow the nodes of information that subjects will need to answer to the task-test. Correlation analysis between data variables frequency/time and Search ratio shows an inverse effort. More visits to the map, less relevant search. More time spent in it, less search effort. We stress that Search ratio measures the amount of information accessed by the user that is relevant to the task. Thus, the Search ratio indicates the formation of a mental representation of the relevant information accessed by the user.

However, there is a significant difference between groups of frequency/time and ratios of Orientation and Access. The presence of the map tool was used as an anchor by the subjects. This indicates a long cycle navigation within the web, determined by the map and not by the relevance of the information to the individual performance. Correlation data between frequency and time in the map (the highest score 0.928 from the data), showed no evidence to the task resolution and could be interpreted as an indication of the cognitive overhead to the groups of the highest frequency. Subjects in this condition attribute the control of their performance to the system, as we may conclude by the results to the task-test, which had no significant difference to the three groups of frequency and time in the map. We may conclude that the amount of frequency of visiting the map and time spent in it does not mean orientation in the process of organizing and acquiring relevant information.

These findings are consistent with the suggestions of [Stanton et al., 1992], who argue that the provision of a map result in poorer performance, less use of the system, lower perceived control and poorer development of cognitive maps, when compared to a condition with no map present. Nevertheless, we used another research design that not includes the representation of cognitive maps. Perhaps it is not wise to assume that a map that helps performance in a spatial context also form an aid to a hypermedia environment.

References:


Assessing the Learning of Distant Students: Competency-Based Instruction

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Abstract: To assess the learning of students participating in distance learning we propose Competency Based Education (CBE), by which we mean that student learning is assessed with respect to published competency statements consisting of explicit criteria and standards that student work must meet. We explain how competency based education lends itself to the student of WWW-based distance learning and to the assessors of such learning. The College of Public and Community Service at the University of Massachusetts/Boston assesses all student work with this competency-based method.

Knowledge is not independent but, rather fundamentally situated, being in part a product of the activity, context, and culture in which it is developed. [Brown, Collins, & Duguid, 1988]

The reach of educational institutions is expanding via the World Wide Web (WWW). Many universities offer some on-line courses, and some universities (for example, Walden University, Minneapolis MN) offer only on-line courses. As universities' educational reach expands, their notion of student must expand as well. Students who participate in distance learning are often adults with full rich personal lives and jobs, and they seek education to improve their lives and jobs. Students' lives and jobs should be perceived not as an impediment to their education but as an additional resource for educators. These students are precisely in the position that current learning theories, such as situated learning [Clancey, 1993], and apprenticeship learning [Gardner, 1991] claim is ideal. These theories and models of learning describe instructional methods suitable for distance learning over the WWW, but have little to say regarding appropriate methods for assessing or evaluating student learning.

In traditional educational settings, the instructor has ample opportunity to directly observe each student asking questions, handing in homework, making presentations, and taking quizzes and tests. The instructor can be reasonably certain of the student's mastery of the subject matter. Educational media such as the WWW now extend the classroom beyond the traditional four walls and a student's work may be performed entirely outside the instructor's view. Nevertheless, in many cases, the task of assessing student learning for the purposes of providing feedback to the student and certifying that the student has acquired a body of knowledge and can suitably apply it will remain for the instructor.

There are several alternate methods of assessing student learning via the WWW:

- One might simply ignore assessment; millions have learned to use personal computers without receiving formal instruction, assessment, or credit
- One could use formal standardized tests, such as the SAT and GRE subject tests
- One might use take-home tests, student projects, and portfolios
- Finally, one could use the method we advocate here: competency-based assessment, as practiced at the College of Public and Community Service, University of Massachusetts, Boston (CPCS).

To graduate from CPCS a student must develop and complete an approved learning plan for attaining some 50 competencies, (from a set of some 300 competencies developed by the College) complying with a set of degree requirements that we shall not delineate here. Instead we focus on the nature of a single competency statement and provide an example of how a student might go about attaining it in a WWW based distance learning situation. Competency-based assessment of student learning, as practiced at CPCS, is the product of over 20 years of educating adult students who have little time to spend on campus. Credit is awarded when students prove themselves competent according to the standards and criteria of a competency statement. While adult students must determine their own time, place, and rate of study, CPCS provides a number of services supporting adult student learning, including competency-based assessment.
Competency-based assessment is different from other assessment methods in that it takes place throughout the learning process. As the example below will illustrate, assessment is more than an event that occurs at the end of a semester. Assessment begins when the student decides to undertake the competency and continues until the student has acquired the knowledge and the competency is granted. Unlike semester-based courses, attaining competence is not force-fitted to an administratively convenient lock-step time span, but takes place at a rate proportional to the student's effort.

While the student must take responsibility and initiative for learning, the assessor (faculty member) must also work with the student to provide the necessary learning guidance. This can be labor intensive until the student learns the process, then it may fall to as little as a few hours per student per competency.

Instructors can apply competency-based assessment along with whatever instructional method they choose. The change of instructional medium from classroom (or satellite or traditional distance learning) to WWW-based learning opens the door to a variety of instructional approaches, some yet to be discovered. Selecting competency-based assessment does not require a commitment to a particular instructional approach. But committing to competency-based assessment does require working closely with each student, ensuring the student addresses the criteria and standards of the competency statement, and providing professional guidance and scaffolding as the student learns to become a professional practitioner.

Competency-based assessment is particularly suitable to apprenticeship learning and situated learning. Gardner [1991] advocates apprenticeship learning as a means for acquiring performances of disciplinary (or genuine) understanding. To him: "The understandings of the disciplines represent the most important cognitive achievements of human beings"[p. 11]. Gardner summarizes evidence of the failures of current educational practices, showing that students typically leave school with "grave misconceptions and kindred cognitive limitations ... entrenched." Among the remedies he advocates are "apprenticeships, teaching that provides diverse entry points and models, and assessments in context" (emphasis added). Competency-based assessment is an instructional approach that supports the application of each of these remedies.

Clancey [1993] observes "... knowledge does not consist of structures that exist independently in the mind (like tools in a shed). Knowledge, as a capacity to behave, develops during the course of interacting; this is why we say it is situated." The WWW provides the student the opportunity to cease learning theory in isolation in a classroom, a procedure which leaves the student to later discover the relation of theory to practice - a discovery that may never take place. Instead, situated learning via the WWW places the student in a community of practice (co-workers, supervisors, professional societies, and faculty) and provides the student an opportunity to learn theory within that community of practice; to use theory to predict and interpret events, to discuss problems and possibilities with co-workers, to reflect on his or her actions and the actions of others; in short, to comprehend the world from a disciplinary perspective.

The WWW is a communications medium for a community of practice. It is not a broadcast or delivery medium for mass education, but a medium of communication among the parties having an interest in the student's knowledge acquisition process. The student is becoming a member of a community of practice. This process cannot take place in isolation from the community members.

To WWW-based, situated learning, competency-based assessment contributes a clearly stated learning outcome. Each student brings a unique set of circumstances to the learning situation, and each will have a unique learning experience. But all students who persist will acquire the degree of competence outlined by the criteria and standards of the competency statement. Furthermore, such a process suggests that CBE produces self-directed, life-long learners, who can apply their knowledge to the tasks at hand.

In the examples below we consider the role of competency-based assessment for new learning. Note that at CPCS, however, competency-based assessment is also applied to independent study, prior learning, classroom instruction, etc. To begin the process, the student must identify the competency she wishes to achieve, identify a faculty member to work with, and develop a proposal describing how she will meet the standards and criteria of the competency statement. During the competency attainment process she will meet as needed with the faculty assessor and others, as identified in her plan. The attainment of competence requires frequent communication among student, faculty, co-workers, etc., which the WWW can facilitate with electronic mail; text, voice and video conferencing; information storage and retrieval, etc.

An educational program using competency-based assessment will require the development of competency statements with clearly stated criteria and standards of what must be known. It makes no difference whether the learning is situated in a university classroom or in the workplace. Competency-based assessment necessitates that
the focus be on the demonstration of skill and/or knowledge because whatever measurements are used will be linked to or bound by the statements of criteria and standards.

Let us assume that a worker is seeking promotion to a position involving supervision skills; she signs-up through Continuing Education at Local University as a distance learner for a course in Human Resource Management. Since at Local University Continuing Ed, competency-based education is the norm, the student/worker will be demonstrating a competency entitled Supervision Skills. The student/worker will be using the work site to practice the skills involved in supervision and the student/worker's worksite supervisor will be recruited as an assessor of the skills along with the university faculty. The competency criteria and standards will be spelled out in a contract signed by all parties (i.e., the student/worker, university faculty, and work site supervisor). All of this may be accomplished using the WWW. In such a situation, it is easy to imagine WWW-based communications facilitating this process, and conversely, to imagine this assessment process facilitating distance learning over the WWW.

Now, let's examine a full competency statement taken from the curriculum of the College of Public and Community Service (CPCS) and explore how a student might choose to learn and demonstrate the competency via WWW-based distance learning. The competency is Evaluation Design and to complete it a student "can identify the basic issues involved in program evaluation and plan evaluation procedures for community-based programs." The competency statement is taken from the Redbook 1995-96 published by CPCS. The competency was written by the faculty in the Community Planning Center. Please note that most of the competencies used by CPCS are linked to work that students might do as employees within the public sector. In fact, many CPCS students work as providers of service within state agencies such as the Department of Mental Health, Department of Social Services, etc. or community agencies such as Boston City Hospital, Alianza Hispana, etc. or are recipients of the services of such agencies. There are three main criteria that the student must address and six standards that the student must meet in order to complete the competency demonstration. The criteria are:

1. Describe a particular community-based program, including the size of the staff and budget, the services offered, the objectives of the program and the organizational form (i.e., non-profit, cooperative, etc.).
2. Design an evaluation for the program according to the following steps:
   a. Define measurable objectives for both program effectiveness and client effectiveness, and discuss who in the program and community should be involved in helping to define the objectives.
   b. Design or select a test or measurement for each of the objectives proposed and discuss how it can be carried out with concern for client's rights.
   c. Select an experimental, quasi-experimental or non experimental research design for the evaluation and justify your selection by giving the specific reasons why the design is most appropriate for the program being evaluated and the strengths and weaknesses of the design compared to alternative designs.
   d. Describe how data will be collected from experimental and control groups including how many clients (or other units) will be in each group, how often and at what points data is collected.
   e. Describe at least one method of qualitative evaluation that is appropriate to the program such as: client feedback, case studies, community surveys, program descriptions, observations, or anecdotes.
3. Describe procedures for obtaining informed consent and for protecting client confidentiality (if applicable).

The standards students must address are:

1. The program selected must be approved by the Center [faculty approval].
2. At least two program effectiveness and two client effectiveness objectives must be identified.
3. The tests or measurements utilized must be referenced and a rationale for their particular use given. If the test or measurement is designed specifically for the particular program, a rationale for its development over the use of existing tests and a discussion of any problems expected to be encountered in its use must be given.
4. The discussion of the strengths and weakness of the design must reflect basic understanding of cause and effect relationships and appreciation of uncontrolled and intervening variables which may bias the outcome of the evaluation.
5. Procedures for informed consent and client confidentiality must meet acceptable standards of professional practice as defined by the federal government and/or such
organizations as the American Psychological Association, American Sociological Association, or National Association of Social Workers.

6. The evaluation proposal must be in a format acceptable to a funding agency which might request such an evaluation.

How might a student demonstrate via the WWW that s/he could meet all the criteria and standards for this competency? The most exciting part of such a demonstration of competence is that it is easily based on work from the student's work setting. In addition, the assessment is ongoing and not limited to one point in time as is true of more traditional assessments. Further, the student and the assessor actually engage in a "dialogue" as the process unfolds. Thus, the learning is continuous and closer to natural learning processes. For example, once the student identifies the focus of the evaluation, the student's work site supervisor participates with both the student and the university assessor in the process. This helps to assure that the information gathered for the evaluation is accurate. In addition, it is a means of making certain that the work is indeed the student's. Further, it increases the likelihood that the information gathered is of use to the agency. The value here is that the student demonstrates competence using a real work situation.

Of additional interest is the opportunity for the university assessor to begin a discussion with all parties - that is work site personnel and /or clients but most especially the student about the actual workings of the program evaluation. Questions are raised about the choices the student makes and the student has the opportunity to consider additional information regarding key decisions in the evaluation design. For example, as the student addressed criteria 2c (selecting the appropriate design for the evaluation), she actually engages with the university assessor about how the design should be organized. How are the interests of the different parties to the proposed program evaluation addressed in a fair and equitable manner? How are the "voices" of those served heard? How are the concerns of management recognized? How are all of these integrated into an evaluation design? What are the drawbacks? What are the strengths? What does the agency gain from such an evaluation of its program(s)? In other words, how does the student defend her choices and present them in a manner acceptable to the agency or funding source (standard 6)?

Clearly, the advantage of such assessment of learning is that it occurs in steps that reflect how one actually learns. As questions or concerns arise, they are dealt with and the learner is not penalized because of a misunderstanding or the need to develop her thinking a little further in a particular area. The assessor challenges the learner positively. Assessment becomes the logical extension of the learning process and not its end. The key to competency-based assessment is that it is linked to the statement of competence (criteria and standards) that learners must address and that assessors of learning must follow. However, what is contained in the statement of competence can be negotiated prior to the beginning of the assessment process. Here, too, such negotiation would involve assessor, student, and workplace personnel.

It is our contention the competency-based assessment lends itself to adult learning situations particularly because it can easily be adapted for use in the workplace. Because no assumptions need be made about how, when, or where the learning takes place, the focus can be on the demonstration of competence. Both learner and assessor are then free to take full advantage of the learner's particular work setting. The result is more likely to be a positive learning experience for all involved; it is also more likely to be respectful of the expertise the learner brings to the situation.

Competency Based Education is the answer to the assessment of what is learned by students participating in distance learning because in CBE the assessment is linked to explicit statements of criteria and standards that students must demonstrate. Further, CBE allows the learner to take advantage of situated learning and thus to avoid one of the problems of conventional instruction - namely the inability of the learner to apply the disciplinary knowledge outside of the classroom [Gardner 1991]. Finally, CBE is the mechanism to link the use of situated learning to the WWW.

References


An Experimental Comparison of Effects of Dynamic and Static Visual Displays in Computer Based Instruction on Declarative and Procedural Knowledge of Selected Object-Oriented Authoring Skills

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Abstract: An experimental study on effects of animation on types of learning was conducted. A one hour lesson on using an object-oriented authoring language was developed in two formats; static visuals plus text and animation plus text. Sixty two high school students were randomly assigned to one of the treatments. Dependent measures included declarative knowledge (immediate recall), procedural knowledge (completion of the computer task), efficiency (completion time) and confidence of the learner in the use of computers. There were no significant differences between the two groups on the four measures. On the declarative knowledge measure, which was composed of equal numbers of static and dynamic visual items, students scored significantly higher on the static display items, regardless of treatment. It is hypothesized that the incorporation of animation into student assessment protocols may handicap students who may have difficulty with an unfamiliar mode of assessment.

Research on Animation

It is a fact that we will have increasing access to presentation and response capabilities that have never before been possible. Guidelines for the use of these capabilities are not yet available, and on the basis of the current state of research in the field, we can predict that such assistance will take time in arriving. The CAI designer, however, needs to be aware of this impending shift from text-dominated lessons to graphics-oriented presentations where it will be necessary to design new and different interactions. [Siliauskas, 1986, p. 83]

Animation is one component in what is generally referred to as multimedia. Multimedia may be defined as the components of conventional media (computer, video, graphics, animation, audio, color) along with their path to complete integration, which is now just in its infancy. Although the use of 'multi' in multimedia is redundant, it seems to have taken on a life of its own.

This paper examines the multimedia component of animation through a review of the literature and a report on a research study. Research on instructional animation is relatively new but growing; it is important not to let popularity or common misconceptions mislead us should the research support a contrarian view.

A Review of Animation Research

Research Findings

Any widespread belief in the superiority of animation over non-animated instruction within the context of computer based instruction is at odds with the research findings.

Theoretical Basis for the Study

Of the three major theories of learning [behaviorism, cognitive science, and maturation], the former has historically provided the basis for learning from visual displays. Since the early 1970's cognitive science underpinnings have been increasingly employed. The current study follows the cognitive science orientation which proposes that learning is represented in mental models and mental images which arise from memory [Kosslyn, 1980]. Information is represented in memory as mental models which are formed through coding of verbal and image information [Johnson-Laird, 1983]. [Paivio, 1986] proposed that cognition has become specialized to deal separately with verbal and image information. The two are somehow interconnected such that information encoded in both forms is stronger than if coded only in one [Clark & Paivio, 1991]. [Szabo, Dwyer, and DeMelo, 1981] showed that representation of both verbal and visual forms at the time of decoding further enhances the recall of information.

A behaviorist rationale for the study of animation (dynamic visual displays) is provided by [Park & Hopkins, 1993]. They suggested that animation serves to 1] cue and therefore gain the learner's attention, 2] influence an association between the verbal and visual components of the task, and 3] the resulting association would cue performance on unprompted applications.

Methodology

The purpose of this experimental study was to investigate effects of inclusion of animation in instruction on learning procedural and declarative skills associated with object-oriented authoring of CBI lessons by computer based instruction.

Design

The study consisted of a single factor, two-treatment level design with four dependent variables. The independent variable was instructional treatment consisting of text plus static graphics and text plus animated graphics. Instruction was presented on computer. Achievement was defined as recall of information [declarative], creation of the desired product [procedural], time to complete the task, and confidence about computer use. Complete data were obtained on 62 students, thirty six male and 26 females.

Procedures

All students participated in pre-instructional activities related to using computers as part of their regular course. The instruction was delivered on networked Macintosh computers from individual hard drives and did not use color. The visual and verbal presentations were presented simultaneously. Figure 1 shows a sample screen from the instruction materials. This graphic was animated to illustrate the proper procedures for creating a title page for the animation version of the lesson. The animation lesson depicted the mouse actions and subsequent results from properly executing the task. Animation was accomplished with the Spectator™ screen capture program and Quicktime™ and Authorware Professional™ were used for playback.
Instruments and Analysis of Data

The 30 item immediate recall [declarative knowledge] posttest included 15 items SVD which and 15 which used animation and had a Cronbach Alpha reliability coefficient of 0.84. Procedural knowledge was assessed on a 10 point scale reflecting the replication of instructions in the final product. Time was defined as the total amount of time reading the instructions plus the time to complete the task. Computer confidence was assessed through a 10 question Likert scale which is part of the Computer Attitude Scale [Gressard and Loyd, 1986]. Data were collected through computer collection routines and paper and pencil scores.

Findings

Analysis of data via t-test results indicated no differences in scores across the two treatment groups. The achievement means, standard deviations and sample sizes of the three treatment groups by entry ability levels are presented in Table 1 below.

ANOVRM with repeated measures on questions was significant F(1,60)=0.01) with the static graphic group earning the higher score.

Discussion

The results of this study fail to provide support for the hypothesis that dynamic visual displays in the form of screen-capture animations increase learning either of a procedural or declarative task. Before this conclusion is accepted, several alternative plausible hypotheses need to be considered.
### Table 1. Achievement score means, standard deviations and t-tests for two treatment groups on four dependent measures.

<table>
<thead>
<tr>
<th>Dependent Measures</th>
<th>Mean (n=32)</th>
<th>SD</th>
<th>Mean (n=30)</th>
<th>SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural</td>
<td>7.78</td>
<td>6.15</td>
<td>7.90</td>
<td>2.56</td>
<td>0.18</td>
<td>0.85</td>
</tr>
<tr>
<td>Declarative</td>
<td>16.56</td>
<td>6.15</td>
<td>17.70</td>
<td>5.07</td>
<td>0.79</td>
<td>0.43</td>
</tr>
<tr>
<td>Time (hours)</td>
<td>0.63</td>
<td>0.20</td>
<td>0.68</td>
<td>0.16</td>
<td>1.11</td>
<td>0.28</td>
</tr>
<tr>
<td>Confidence</td>
<td>30.19</td>
<td>6.41</td>
<td>30.87</td>
<td>4.08</td>
<td>0.50</td>
<td>0.62</td>
</tr>
</tbody>
</table>

### Table 2. Scores on static, dynamic and combined questions on recall posttest.

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean (Static)</th>
<th>SD</th>
<th>Mean (Dynamic)</th>
<th>SD</th>
<th>Mean (Combined)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Questions</td>
<td>8.72</td>
<td>3.14</td>
<td>7.63</td>
<td>3.54</td>
<td>16.56</td>
<td>6.15</td>
</tr>
<tr>
<td>Dynamic Questions</td>
<td>9.33</td>
<td>2.38</td>
<td>8.40</td>
<td>3.28</td>
<td>17.70</td>
<td>5.07</td>
</tr>
<tr>
<td>Combined</td>
<td>9.02</td>
<td>2.80</td>
<td>8.00</td>
<td>3.41</td>
<td>17.11</td>
<td>5.64</td>
</tr>
</tbody>
</table>

### Table 3. Correlations Among Dependent Variables

<table>
<thead>
<tr>
<th></th>
<th>Success</th>
<th>Recall (static)</th>
<th>Time</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success (procedural)</td>
<td>1.00</td>
<td>0.54*</td>
<td>-0.20</td>
<td>0.34*</td>
</tr>
<tr>
<td>Immediate Recall (declarative)</td>
<td>1.00</td>
<td>-0.09</td>
<td>1.00</td>
<td>-0.21</td>
</tr>
<tr>
<td>Time</td>
<td>1.00</td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

* p<0.05

First, there is the suggestion that the task was too easy for the participants. This contradicts the findings of a pilot study in which the dynamic group performance was higher than the static group. The study should be replicated with either less advanced students or more difficult authoring tasks. As an extension, the study could be expanded in duration to permit additional variation, if it exists, to be observable.

Success Recall Time Confidence

<table>
<thead>
<tr>
<th></th>
<th>Success</th>
<th>Recall</th>
<th>Time</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.54*</td>
<td>-0.20</td>
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<tr>
<td>Time</td>
<td>1.00</td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

Since the SVDs were snapshots of selected frames of the DVD used in this study, it might be hypothesized that the former captured the essence of the power of instruction and, combined with text, accounted for an equivalent amount of variance in the outcome scores. This hypothesis might be tested by varying the number of SVDs in proportion to the amount of DVD presented to the learners.

Previous research suggests that learning under CBI is as good as or better than learning under conventional instruction. Perhaps the treatment variance explained by the visuals was so small in comparison as to be undetectable by the current instruments.

The disparate findings between the static and dynamic portions of the recall examination in which the static group scored higher than the dynamic group has some implications. As multimedia penetrates the classroom in greater amounts, sooner or later, the frequency of dynamic visual testing will increase. Eventually it will become commonplace and students will learn to function in its presence. During the transition, however, perhaps educators should consider teaching students how to function under dynamic visual testing situations.

Finally, we observed a low correlation between computer confidence and both procedural and declarative knowledge scores, contrary to what one might expect. Given the historical high correlation between attitude and knowledge, this is a finding which should be explored further.

This paper is based on the research completed in partial fulfilment of the M. Ed. in Instructional Technology, Advisor, M. Szabo. Contact M. Szabo for a full copy of the paper.
References


Abstract: Colleges and Universities are under pressure to improve their programs, make them more accessible, and control costs. Many are considering instructional technology (Alternative Delivery Systems). Large scale implementation has been unsuccessful due to three factors: knowledge and application of technology, supporting infrastructure, and working understanding of the process of change. Inability to bring about change is the most troublesome and difficult to deal with of the three. A program to advance ADS by dealing with these three factors has been developed. One major feature of the program is the creation of temporary Task Forces (TFs), with apriori support, to provide leadership to departments. TFs are trained to become exemplary users, train and support colleagues, and develop multi-year changeover plans. The program emphasizes professional development, ownership of change through empowerment, multipliers to meet the demand, support in a timely and understandable fashion, high credibility, embedded expertise, and leverage of change.

Current Situation and Alternative Delivery Systems

Society in general and education specifically are undergoing fundamental changes which are at the same time vast, confusing, and unparalleled since World War II. What do some of our stakeholders see when they view the educational system from outside?

...education itself will need to change. Schools and universities will need to replace their outdated reductionist forms of learning with the cross-disciplinary knowledge necessary for riding the information networks of the future. [Burke, 1994, p. 13].

Each of us has more machine power available at a fingertip than any Roman Emperor, a single CD-ROM can carry the whole of Renaissance science and philosophy and information can be sent around the world easily and in an instant. Polanyi [1994] provides a glimpse of what it will mean.

The fact that the necessary information comes to the student on demand, rather than as part of a forced diet, will have the consequence that it is more keenly desired. In addition, the flow of information will be matched to the capability and appetite of the student. Further, there can be an open invitation to the student to apply newly encountered principles at an early age, without fear of ridicule. Even partial success in this game of simulating understanding can be counted on to reinforce the learning process in a spectacular way. Taken together, these developments present an unparalleled opportunity for education. [Polanyi, 1994, p. 32-33].

The impact of information technology outside of education is well known. But how is education responding to these new opportunities? The difficulty of attracting significant numbers of teaching faculty to the use of Alternative Delivery Systems (ADS) has been recognized by many.

The big story for the field of educational technology in the field of education and training is not what marvelous new technology we educators have at our fingertips. The big story is the slow take up of this technology and the challenge this poses for educational managers. [Mitchell, 1992, p. 81].

Alternative Delivery Systems Defined

Alternative Delivery Systems (ADS) 1) use instructional technology and 2) provide different ways of organizing and delivering instruction (education and training) from the conventional instruction ADS is comprised of Presentation, Interaction, and Communication.
Situation Analysis

Examination reveals little or no use of ADS. As observed by [Rossman, Corbett and Firestone, 1988], adults are experts at pretending reform is taking place without vesting any ownership in the process, especially when there are sanctions for not changing. ADS is highly innovative and forces us to re-think our models of how people learn.

Three factors associated with the lack of use of ADS are 1) inability to use rapidly changing instructional technology, 2) lack of infrastructure and support, and 3) unwillingness to change. Of these three, the last is the hardest to overcome but the most important, relatively speaking.

Fullan [1991] observed that educators are neither trained nor expected overcome the major sources of resistance to change and change typically involves punishment rather than reward. Resistance to change is a natural response to changes in the environment over which people have little or no control.

Senge in his book and program known as The Learning Organization [Senge, 1990], has identified one key to unlocking the power of innovation: the explication and testing of hidden mental models. Szabo [in press] has identified some mental models which may inhibit the use of ADS. Examples include: 1) change to ADS can be done by individual faculty members working alone, 2) ADS technology is limited to certain courses, content or assessment protocols, 3) instructors will actively contribute to someone else’s goals and visions, 4) electronic communications is an inadequate substitute for face-to-face instruction, 5) normative assessment is the only valid model of assessing student learning, and 6) society and funding agencies are content with our ability to disseminate our expertise.

Other issues are related to a positive climate for change, such as empowerment, the TF-Leadership Team structure, and so forth. These issues are presented later as Leadership Skills Modules.

The lack of infrastructure is but a symptom of a deeper problem: decision makers have neither a strong vision of what instruction can become under ADS nor a willingness to commit to the necessary resources. Faculty sense this lack of vision/commitment and focus their efforts on projects which are valued.

ADS cuts across all subject matter and age levels and affects every person with instructional responsibilities. Training and supporting such numbers of individuals is a huge logistics.

Finally it is difficult to justify hardware, software and other infrastructure when ADS instructional materials have not been developed, vice versa.

This program is based on several key principles of change.

1. Change cannot be separated from professional development of our major resource-the intellectual capability and leadership of our personnel.
2. People most affected by the change must be empowered to make the decisions and control the direction the change proceeds.
3. Change is driven by the development of a mutually shared vision of what could be.
4. Change requires commitment and sacrifices which should be visibly embraced by all affected.
5. Change involves taking risks and taking risks involves making mistakes; people should be encouraged to take calculated risks, certainly not penalized.
6. Change must be concentrated in areas where there is maximum leverage.

A Program for Change Through Professional Development

This program addresses a variety of factors which have historically inhibited change in instruction. The bias, however is clear: change is the major factor and the program addresses change based on the latest information available about change. In formulating the program, years of research and practical experience from the change, innovation, and leadership literature were consulted. Many of the ideas have been tested in previous work by the
author in the context of a different type of instructional innovation. In an attempt to describe how the components fit with a familiar analogy, I have chosen the onion, with its central core and surrounding layers.

The Onion Analogue

The program is analogous to an onion which has a central core, surrounded by several layers which provide protection, support and nourishment.

In this analogy, central core is a Task Force (TF) and the layers refer to a Leadership Team, Department, College and University level administration functions as shown in Figure 1. The core and layers will be described below. Intertwoven are submodels from the administrative viewpoint as well as from the faculty or entrepreneurial standpoint.

Central Core: The Task Force

The TF is the heart of the change model and is defined as a team of faculty who are willing to receive preparation to provide leadership and support to colleagues on behalf of their department. Here I will briefly describe the key elements of what the TF is expected to do and the rationale for these actions.

![Figure 1. A Cross Sectional View of the Onion Layer Program of Change With Respect to ADS.](image)

What

The Terms of Reference of the TF are to significantly expand the use of appropriate ADS among the majority of members of their department. A TF consists of people within a department, who are temporarily assembled and empowered to respond to a new opportunity or challenge facing that unit. They continue to carry on with much of their work load and return to their former positions once the challenge has been met.

The TF is Accountable to carry out four tasks: 1) be exemplary users of some form of ADS in their own instruction, 2) actively train colleagues in the use of ADS, 3) provide on-the-spot support for colleagues, and 4) develop multi-year changeover plans to guide the department. The only constraint is that the actions fit within the broad parameters of the overall vision. TFs undertake realistic tasks which can be accomplished within their capabilities. Since ADS are highly innovative, innovation requires risks, risk entail some failure, administration must be tolerant of inability to reach all goals. When risk is tolerated, faculty are emboldened to try new approaches, to develop new ideas, and to provide leadership.

The TF functions as a Team. Bringing about widespread increases in the use of ADS among all members of the department is too big for one or two individuals to carry out. A team effort is required.

The TF’s Composition or selection criteria is crucial. It must include the active participation of the key departmental administrator and opinion leaders among teaching faculty. The curriculum specialist should be a member, as well as individuals who have had some experience with ADS.
The TF provides **Leadership** in the use of ADS through modeling, training, and on-going support in a just-in-time fashion at the level of the individual user. Successful transformations begin to involve large numbers of people as the process progresses.

Each TF is based and works within a given **Department**. Research has shown that power to make or break innovation resides in the department rather than at the college or central administrative levels. This model leverages the power of change by applying it where the greatest impact can be made.

The TF must have **Resources** to enable them to carry out this challenge, including training and on-going support. The training includes the 'hard skills' of ADS and the 'soft skill's of change. This training is carried out by the Leadership Training Team (Layer 1) as described below. Third, the other levels of administration must be prepared in advance and this is a function of the Leadership Training Team.

**Rationale**

When **Professional Development** is emphasized, the potential for change is greatly increased. This model **Empowers** the TF and encourages ownership of the change process. This system capitalizes on the **Knowledge** of the strengths, weaknesses, personnel, policies, and goals of the **Department**, which is possessed by the members of the TF. TF members become leaders and trainers who act as **multipliers** to provide training to the large numbers of colleagues. The most frustrating thing about working with ADS is that at a beginning level of knowledge, problems which are minor to the experienced can be demoralizing. The second most frustrating aspect is the inability to obtain support in a timely fashion which can be understood by the layperson. The TF, being in the department, will provide this assistance in the form of support. The results will be more **credible** because they were attained by people from the department, charting their own course. Long range plans, assembled by the TF with its newly acquired knowledge and joint planning with administration are likely to be more realistic, appropriate and thus carried out. Finally, when the TFs job is done, its members return to their previous work responsibilities. This **embeds expertise** within the department for future use and avoids the creation of additional administrative units. Change is **Leveraged** by concentrating efforts at the place where it is most susceptible to success-the department.

**Layer 1: Leadership Team**

An Institutional Leadership Team directs and coordinates the efforts of this program. It is comprised of a focussed team of experts in the field of ADS and change, plus an external consultant or two to guide the process. As with the DepartmentTFs, this group will dissolve upon completion of its tasks.

**Set the Stage for Change Across the Institution**

The first major task of the Leadership Team is to set the stage for change across the institution at the Central, College and Department Levels of Administration through a service of “Visioning” sessions.

**Work with Departments to Identify, Train and Support Task Forces**

The second major task involves working with several departments to identify TF Members and complete their training in the hard skills of technology use and the ‘soft skills’ of application to curriculum, instruction and evaluation, and leadership. Finally the Leadership Team provides long term support to TFs as they carry out their plans.

**The Technologies below employ self-paced Modules which teach how to use the technologies**

**Alternative Delivery Systems Technology Training (Hard Skills)**


The Distance Delivery Technology (D) Modules of D1: Audio Conferencing  D2: Video Conferencing  D3: e-mail  D4: Listservers


Alternative Delivery Systems Leadership Training (Soft Skills)


The Leadership Team supports information and technology exchanges across TFs and to administration. Progress will be shared with the profession through presentations and appropriate forums.

Layer 2: Department Administration

The Leadership Team will seek to promote several goals and activities with administrators of Departments. These will include 1) develop a departmental vision for ADS through participation in the TF, 2) communicate the vision to the larger department body, 3) commit resources to the project, 4) provide appropriate incentives to the TF and other ADS efforts, and 5) express interest throughout via personal involvement and review of progress.

Layer 3: College Administration

The Leadership Team will seek to promote several goals and activities with administrators of the Colleges involved. These will include 1) develop a vision for ADS within the College, consistent with the vision of Central Administration, 2) communicate the vision to the Departments within the College, 3) commit resources to the project, 4) enable appropriate incentives to the TF and other ADS efforts, 5) express interest throughout via personal involvement, and 6) review progress and plans of each Department.

Layer 4: Central University Administration

The Leadership Team promotes similar goals with the Central Administration, including 1) develop broad parameters of a vision for ADS within the University, 2) communicate the vision to the Colleges, faculty, staff and external stakeholders, 3) commit resources to the project, 4) enable incentives to the TF and other ADS efforts, 5) express interest throughout via personal involvement, 6) review progress and long range plans of each College and develop an infrastructure plan, 7) form alliances with vendors and suppliers for complementary benefits, and 8) develop policies commensurate with ADS structures.

Benefits of the Program

The first benefit of the program is the payoff from growth and development in the faculty. The University’s only resource the ability of its personnel to create and disseminate knowledge to the rest of society. The second benefit is improved instruction because active participation in ADS will cause faculty members to re-examine how they view and deliver instruction and programs. The third benefit is increased accessibility by society to the
knowledge of the university through alternative delivery of current knowledge in a timely fashion. The lower cost benefits of using technology to deliver instruction will result in controls on escalating costs and greater acceptance by the public and funding bodies. Finally, the residue of the program will be pools of expertise in every participating department. These pools of expertise will enable the institution to continue to keep up with or stay ahead of the continuous change which we anticipate in the technology and techniques of ADS that will surely come our way.

References


Appendix A: Definition of Alternative Delivery Systems

Alternative Delivery Systems

Presentation Technology
Word Processing Applications
Presentation Applications
Static Visual Displays (SVD)
Dynamic Visual Displays (DVD)
Audio (A)
Device Integration
World Wide Web Pages

Individually Interactive Technology
Computer Based Instruction (with SVD, DVD, & A)
Computer Assisted Instruction
Tutorial
Review and Practice
Simulation
Computer Managed Instruction
Diagnostic Assessment
Prescriptive Study Assignments

Group Communication Technology
Audio/Video Conference
e-Mail
ListServers, BBS
HyperMed: A Hypermedia System for Anatomical Education

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Abstract: Multimedia and hypertext had and still have great impact on the evolution of educational software. On the other hand there has been a spate of interest in employing both multimedia and hypertext in health care, but unfortunately systems for education in central fields of medicine are not available or have not been satisfactorily dealt with. Basing upon this observation two institutes at the University of Dortmund and the Essen School of Medicine started a conjoint project in the area of educational software in anatomy. The resulting hypermedia system, called HyperMed, is presented in this paper. In our opinion both students and teachers will benefit from such a system. The paper briefly focuses on the traditional way of teaching gross anatomy, introduces the current version of HyperMed, summarizes the evaluation of the system and closes with an outlook on future developments.

1. Introduction

In this paper HyperMed, a hypermedia system for anatomical education, is presented. HyperMed was developed at the Department of Computer Science at the University of Dortmund in cooperation with the Department of Anatomy at the Essen School of Medicine and it is based upon a formal model for hypermedia published in [Tochtermann & Dittrich 95] and [Tochtermann & Dittrich 96].

The aim of the project is to improve education in cross-sectional anatomy which is a special field of gross anatomy. The courses in gross anatomy are a traditional central and indispensable part of the curriculum of medical students which introduces them into human anatomy. Recently, these courses are increasingly supplemented by classes on sectional anatomy which are needed to prepare students better than before for the interpretation of MR- or CT-images (magnetic resonance images and computer tomography images). In cross-sectional anatomy undergraduates have to understand and identify very complex structures in horizontal sections of the human body. In addition they have to locate the same structures in corresponding MR- and CT-images.

The task is difficult because of the similarity and complexity of some tissues.

During courses in cross-sectional anatomy at the Essen School of Medicine participants study slices of a human body and they have to identify the organs and structures therein with the support of books, collections of photos, and tables [Hohn et al. 95]. This is quite time consuming and poses problems since only a small number of students can study a section at a time so that many groups of students have to be taught at the same sections consecutively. Thus, a major drawback is given by the fact that usually institutional budgets do not allow extensive supervision by departmental personnel or student tutors as would be necessary. We therefore decided to develop a hypermedia-based courseware for the undergraduate course in cross-sectional anatomy at the Essen School of Medicine which is designed to supplement this type of teaching program effectively.
The article is structured as follows: Section 2 gives a brief overview of hypermedia and education and introduces terms used in the paper. Section 3 stresses the functionality of HyperMed and section 4 explains some technical details of the system. In section 5 our work is related to existing literature. The students’ experiences with the system are summarized in section 6. Finally, section 7 concludes the paper with a brief outlook on future developments.

2. Hypermedia and Education

First attempts to combine computers for educational purposes go back to the early sixties and terms like courseware, computer assisted instruction, computer based learning, or computer based teaching, to mention only a few, were coined. In this paper we only use the term courseware as an embracing term for any kind of educational software.

Due to expensive hardware and lack of graphical interfaces most of the early approaches, e.g. PLATO from the University of Illinois, were not very successful. This situation changed dramatically in the late eighties, when workstations with graphical user interfaces appeared on the market. In addition, multimedia and hypertext became more and more popular, so that lots of educational software have been developed using these new technologies and concepts.

Hypertext is a concept of information management in which data is stored in a network of nodes connected by links. The origin and destination of a link is referred to as an anchor. The navigational interface and a very simple structure allow users to easily handle the information in a hypertext. Multimedia may generally mean any mixture of different media, e.g. video and sound, and from a user-centred perspective it offers possibilities for manipulating richer information using natural sensory abilities. Hypermedia combines hypertext and multimedia, namely synchronized media that additionally have links between their components.

Apart from others, hypermedia-based educational software offers the following benefits:

• Animation can be used to illustrate complicated facts.
• Users can freely navigate through the courseware. Hence, students can learn by exploring the material.
• Hypermedia-based courseware can be interactive, and can respond to the students with evaluations of decisions taken.
• Using appropriate view concepts [Tochtermann & Dittrich 95] different levels of the hypermedia-based courseware can be offered to students with different experience.
• Simulation models are one of the most effective applications of computer-based instruction [Corvetta et al. 91]. They can easily be integrated in hypermedia systems.

However, to create good courseware it is not sufficient to dominate the technology. In addition, experts from various fields are indispensable, e.g. pedagogues, experts in the application domain of the courseware, experts for evaluation purposes of the courseware.

Therefore the consortium being involved in the development of HyperMed consists of computer scientists from the University of Dortmund. In addition, our partners from the Essen School of Medicine provide knowledge for advising and designing the courseware, physicians (anatomists) for providing anatomical information for the courses, and experts in statistics for the evaluation.

3. Description of HyperMed

HyperMed differentiates between authors, i.e. physicians, and readers, i.e. students, of hypertexts and offers functionality adapted to the personal needs of both groups.

3.1 Authoring with HyperMed

Authors (physicians, anatomical teachers) must be able to insert and expand existing data without knowing details of the overall program structure. Thus, HyperMed consists of an environment of "small" applications rather than integrating the entire functionality within one application.

For creating the material for a course, authors are provided with different editors which do not depend on the hypermedia functionality of HyperMed. Text files can be created by using standard editors or text processing systems, e.g. MS Word. Similar to HTML, we use a simple markup language to define the text layout, link anchors etc. The idea is that authoring tools must be easy to use for the teaching staff. Another advantage is that for further extensions of HyperMed these markup languages can easily be converted into HTML so that HyperMed documents might be distributed via WWW.
Although any graphic editor can be used, we developed a special JPEG editor. It meets some requirements that are important for courseware in gross anatomy. Not only does the graphic editor allow the author to integrate new graphics or a photography of a cross-section, but the author can also identify structures in such a photography by outlining the structure's shape. The editor provides standard 2D-operations like freehand drawing, circles, rectangles, polygons etc. to define the shape of an object. Such a shape may serve as an anchor for a link.

The idea of defining links bases upon a simplification of the Frame-axis Model [Masuda et al. 94]. Within each node (frame in [Masuda et al. 94]) authors define anchors. An index (axis in [Masuda et al. 94]) is used to map nodes with defined anchors onto other nodes. The index is created as follows: For images the authors must define important structures within the image. These structures are described by index terms and the index terms are added automatically to the index. For texts, authors have to add intellectually index terms to the index. To give two examples: When the author defines an origin for a link within a text, e.g. the word “liver”, the program looks for corresponding entry in the index and connects this origin with all documents or all structures within images which are indexed by this word. When the author defines the origin of a link within an image, he has to outline the shape of a structure and he has to add an index term for this shape (if not already done). On the basis of this index term, the system then defines one or several links to appropriate textual explanations or other images.

In contrast to the Frame-axis Model, our approach only allows 1-to-1 links and 1-to-many links but no n-to-m links (N-ary relations in [Masuda et al. 94]).

### 3.2 Reading documents with HyperMed

At the moment HyperMed provides about 70 MB of compressed data for the course in cross-sectional anatomy. The data consists of about 30 cross-sections of a human body, corresponding MR- and CT-images (one uncompressed JPEG image requires about 7MB), texts, graphics and links. The data is densely interconnected by a rich variety of links (≥1000). One great challenge is to make this information comfortably accessible to the participants of the course. To meet this requirement HyperMed offers different navigational support to the students:

1. **Index-based Retrieval**
   Students can enter index terms, e.g. the name of an organ, and the system returns all texts containing the term or a highlighted structure, e.g. the liver, within a cross-section that has been chosen previously. This requires that an author has attached the entered index term to the structure.

2. **Navigational Retrieval**
   HyperMed provides two levels for retrieving information by navigation. At the macro-level HyperMed provides an image of a human body. Using a horizontal bar, students can select one of about 30 possible cross-sectional planes within this image. The selection corresponds to following a link to a cross-section of this part of the body. As a result, the cross-section including explanations appears on the screen. This feature is often used to start a session with HyperMed. At the micro-level students can freely navigate through the document by following links. With this navigational feature students can learn by exploring the material. Using links students can jump from a structure within a cross-section to its textual explanation. In addition, it is also possible to highlight a structure in a cross-section when a link is followed from an explanation to the cross-section. When a student selects an anchor of a 1-to-many link, a menu appears listing possible destinations. He then selects the desired destination, and the link is followed. For example, the benefit of 1-to-many links is that students can choose the type of an image they want for a given explanation. Hence, time-consuming searching of MR-images, CT-images, illustrations etc. in different books, tables or collections of photos is not necessary.

3. **History List**
   During each session, HyperMed records all visited nodes in a history list. Once a student is lost in hyperspace a known node of the history list can be selected to continue navigation. The history list is also important for the teacher because it gives him an overview of all nodes visited by a student. Basing upon this information he can advise students what other nodes are important for the current session and should therefore be visited. This part of the program also performs statistics anonymously for each user to what extent different components of HyperMed are used.

The following figure shows a screen shot of the user interface of HyperMed. On the right, HyperMed provides readers with the possibility for macro-navigation as described above. The buttons on the left can be used to select the type of image, e.g. cross-section, CT-image, or MR-image, which is displayed in the upper middle of the user interface. Finally, textual explanations for the displayed images are given in the lower part of the user interface. The history list can be found on the left-hand side of the textual explanation. In this example, a pop-up menu
offers the different destinations of a 1-to-many link to the user. The user can select an entry and the corresponding destination will be displayed on the screen.

Figure 1: User Interface of HyperMed

4. Platform and Technology

HyperMed was developed by using the C++-language (Microsoft Visual C++ 2.0) under the operating system Windows 95. Windows 95 is well accepted and will be (or even is already) in widespread use so that students can install and try out HyperMed even at home. The underlying formal model [Tochtermann & Dittrich 95], [Tochtermann & Dittrich 96] favours the use of a concept of independent components, i.e. text, graphic, video etc. The idea of this concept is to use special applications for creating these components rather than integrating the entire different editors within the hypermedia system. To follow this line, we decided to use the OPENDOC-standard for compound documents. For instance, this allows us to employ any JPEG editor for editing our JPEG images. Another advantage is that the created software and object library can easily be extended for further improvements and reused for other projects. Finally, we used the class library MFC 3.0 for the administration of graphical I/O. All other objects were created platform-independently.

5. Related Work

Since a lot of papers on hypermedia and medical education exist, e.g. [Corvetta et al. 91], [Cleynenbrengel et al. 95], we only focus on three systems that influenced our work. Hyper-G is a second generation hypermedia system and has been developed at Graz University of Technology [Maurer 96]. The Hyper-G clients, Harmony and Amadeus, provide image viewers for common formats, including JPEG. Similar to HyperMed, both clients also allow overlapping anchors in JPEG images. Furthermore, link anchors in image documents may be rectangular, circular, elliptical, or polygonal in shape. In
addition, HyperMed also allows free-hand drawn anchors, a feature that is helpful for outlining an uneven structure in an enlarged cross-section. However, Hyper-G is a hypermedia system especially designed for applications consisting of tens of thousands of documents (nodes) and links. Compared to typical Hyper-G servers, HyperMed only provides a small amount of nodes and links. Finally, most of the students working with HyperMed are computer novices so that our colleagues at the University of Essen, preferred a easy to handle frame-based user interface to the multiple window interface of the Hyper-G clients.

The WAL T system developed at Washington University [Frisse et al. 91] provides a research environment for medical hypertext. In contrast to HyperMed the emphasis is placed on hypertext and information retrieval in clinical and basic medical research but medical education is not supported. However, we plan to integrate ideas, e.g. metaphors from the WAL T interface or path clipboard, from the WAL T system in later extensions of HyperMed.

At Cornell School of Medicine a system called PathMac was used to make the learning process more efficient [Diaz 91]. Students taking the course in Introductory Pathology can enrol in an electronic version of the course. Selected material for other courses, like biochemistry, anatomy radiology is available. Similar to HyperMed, students can study anatomy or compare images of normal organs against abnormal tissue cells. Unlike HyperMed, PathMac provides sophisticated simulation tools, i.e. a patient simulation tool and a tool to perform simulated laboratory experiments. However, to our knowledge, PathMac does not allow to define arbitrary regions in an image, in our case a cross-section, as an anchor for a link. In addition, PathMac includes applications written in HyperCard, Guide and other tools developed in-house. Furthermore, HyperCard and Guide are not appropriate for our requirements: both systems do not support compound documents (c.f. section 4) and the performance of these systems is too low for our needs, e.g. uncompressing of a compressed JPEG cross-section (about 300 Kbytes) which results in a high resolution cross-section (about 7MB).

### 6. Evaluation: Practical experience made with HyperMed version 1

In the winter term 1995/1996, the first version of HyperMed was used for three months as a tutorial for the course in cross-sectional anatomy which is a part of the dissecting course. During these classes about 200 undergraduate medical students were, on one hand, taught cross-sectional anatomy the traditional way (as described in the introduction) by student tutors for a defined time. In addition, however, they had free access to five workstations for using HyperMed.

HyperMed was very well accepted by the students. All students stated that the program is easy to handle. This was even confirmed by people who had never used a computer before. Such users usually got acquainted with HyperMed in about 15 to 20 minutes. As a rule the students expressed that working with HyperMed was much more convenient than using textbooks and anatomical atlases or waiting for the (only temporarily available) help of tutors in order to identify structures in cross-sections. It has been found a great advantage to have free access to HyperMed as a computerized tutor than being restricted to the very limited classhours when help form student tutors was offered (as in the traditional course for cross-sectional anatomy). Although the majority of feedback from the students was positive they also made some suggestions for improvement: Most of the users asked for a mode for selfexamination in order to control their success in learning and understanding. Others were also missing statistics telling how much of the available information had been seen by an individual user so far.

Indeed, this type of information can and will be offered by HyperMed: Any user of HyperMed gets access to the program by an individual password. Based on this, the computer creates an anonymous record for each user and performs statistics to what extent any component of HyperMed is used. This information will be made available to students in the future. The records will enable us to define whether different groups of users use the program differently and whether certain components of HyperMed are used more frequently than others. All these statistics will direct our attention to parts of the program that ought to be improved or extended. Unfortunately, these records could not be evaluated so far because the courses had not been finished at the time this paper had to be submitted. Furthermore, at the end of the classes students will also be requested to fill out a questionnaire asking for their opinion concerning different aspects of HyperMed.

### 7. Outlook

After HyperMed has been used successfully as a tutorial in cross-sectional anatomy we are planning to extend it as follows:

1. HyperMed was developed originally in order to create a computer-based tutorial for teaching cross-sectional anatomy preparing undergraduate medical students to understand radiological images. In a collaboration with
radiologists HyperMed is now being extended so that radiologists can use the system in their clinical day-to-day work. Similar to the WALT system [Frisse et al. 91] HyperMed should serve as a research environment and should allow clinicians to retrieve medical information in a way that satisfies their personal needs. This extension can be regarded as a step towards an anatomical and radiological digital library.

2. As a response to the feedback from the students we will integrate functionality for selfexamination.

3. At the moment HyperMed does not provide real multimedia. The program provides the possibility, however, to integrate MPEG videos, audios and 3D-scenes, which are of great value for physicians, and this is in preparation. Like in Hyper-G, it should also be allowed to define link anchors in these types of media.

4. Novel ideas of the RIME system [Berrut et al. 95] for indexing of medical images could be integrated. Given an existing image, such an approach may help to find similar images. For example, this may be of great value in diagnosis.

5. Finally, HyperMed is a hypermedia system without any “intelligence”. We are planning to incorporate intelligence to the system to get an expertmedia system [Rada & Tochtermann 95]. For example, defining an anchor, e.g. the cerebellum, in an MR-image can be done automatically if the system is able to find this region in the MR-image. Our first results of finding structures in MR-images are based on techniques of computational intelligence, i.e. fuzzy logic, genetic and evolutionary algorithms [Fathi et al. 94]. Knowledge bases can also be used to define links automatically.

8. References


The Effects of Different Computer-based Instructional Modes on Students of Different Cognitive Styles

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Abstract: The purpose of this study was to investigate the effects on achievement and motivation of different instructional modes and cognitive styles (field independence and field dependence) in computer-based instruction. The four modes were - Mode 1 (Instruction with graphics, sound and bullet text); Mode 2 (Instruction with graphics, plain text but without sound), Mode 3 (Instruction with sound, bullet text but without graphics) and Mode 4 (Instruction with plain text only). Subjects were 333 students from six Malaysian schools. It was found that there were significant differences in gain scores amongst students from the different instructional modes with students in mode 1 obtaining the highest score. The study found no significant differences in gain scores between field dependent and field independent students. Furthermore, it was found that there were significant difference in motivation between students from the four modes with students in Mode 1 obtaining the highest score.

Introduction

Designers of computer-based instruction courseware, often assume that graphics, sound and other non-textual representation almost always play a useful and even necessary role in the development of courseware, and, by inference, the acquisition of knowledge and skills. However, in reviewing the educational, psychological and human factors literatures, there is scant evidence to support this view [Friedman 1993]. Most guidelines for constructing non-textual materials are based on the largely intuitive (an uncritical) assumptions that (a) pictures are good, (b) more pictures are better, and (c) realistic pictures are best all [Dwyer 1972]; [Friedman 1979]. Is this true? Almost all of these reasons are too broadly stated and all can be questioned on empirical grounds. Several other factors are likely to influence learning from computer-based instruction. Previous research has indicated that students' prior achievement, cognitive styles, locus of control, motivation, gender difference are all contributing factors to a student's performance with computer-based instruction. Individual traits of field independence and field dependence so seem to influence the effectiveness of computer-based instruction [Kern and Matta 1988]. While the field independent students generally rely upon internal referents for support in developing a learning strategy, the dependent students must rely upon external referents or guidance in developing learning strategies [Witkin et al, 1977]. In other words, one essential difference between a field independent and a field dependent person is the level of guidance needed by the learner, especially by field dependent students.

Purpose of Research

Given the research concerns discussed in the preceding sections, the purpose of this research was to investigate the effects on achievement and motivation of the courseware on students of different cognitive styles (Field Independence and Field Dependence). This study attempted to find an optimal type of instructional strategy based upon the students' achievement and motivation. Research questions addressed in this study were:-

1. Did the different modes of courseware influence student performance?
2. Was there a significant interaction effect between the different modes of courseware and the cognitive style of the student?
3. Did the different modes of courseware influence student motivation to learn from the courseware?

Method and Design
Description of the Courseware created using the Authoring Tool Toh/Abdul Rahim (TAR)

The courseware entitled "Our Solar System" was created using an Authoring Tool Toh/Abdul Rahim (TAR) which was developed by the author himself using the concept of Object-Oriented Programming. Classes of objects were created which consists of text, graphics, sound, animation and navigational buttons. It had a motivation opening screen to arouse learner's interest; a main menu, and sub-menu with navigation buttons. Simulations were inserted in the courseware as and when required. It had also formative evaluation question and dynamic database comparison.

Design

The basic quasi-experimental design was 4 (Mode of Instruction - Mode 1, Mode 2, Mode 3, Mode 4) x 2 (field independence and field dependence). 333 students from six Penang schools were randomly assigned to one of the experimental treatments. The treatment effects on achievement and motivation of the students were analyzed using ANCOVA.

Independent variables

The independent variables in this study were: (a) mode of instruction and (b) types of cognitive styles. The mode of instruction was considered to be treatment variable and was classified into four modes namely Mode 1 (Instruction with graphics, sound and bullet text), Mode 2 (Instruction with graphics, plain text but no sound), Mode 3 (Instruction with sound, bullet text but without graphics) and Mode 4 (Instruction with only plain text). The cognitive variables included two different types which were field independence and field dependence.

Dependent variables

There were two dependent variables for this study. The first dependent variable was the gain score of the students which was the posttest score minus the pretest score. The second variable was the motivation level of the students as measured by the Keller Instructional Materials Motivation Survey.

Subjects

The subjects in this study were 333 form one students from six Penang schools. For each school, two intact classes were chosen. Within each class students were randomly assigned into one of the instructional modes. There were 194 males and 129 females in this study.

Treatment

The subjects were randomly assigned into any one of the four instructional modes. Instruction with graphics meant instruction with graphics displayed on the top left hand corner of each computer screen. The graphic display could be either static or animated graphics. Sound in this context meant when the text was displayed there would be an accompanying sound to highlight the text displayed. Bullet-text meant that the text was displayed word by word with key-words highlighted by color change. Plan text meant text would be displayed on a screen to screen basis.

Measuring Instruments

There were five instruments used in this study. There were the pretest questions, the posttest questions, the Cattell "Culture Fair" Intelligence Test, the Keller Instructional Materials Motivation Survey and the Group Embedded Figures Test. The pretest and posttest questions consisted of twenty multiple choice questions which were developed to determine student understand of important concepts related to the Solar System. An item analysis was carried out on the results of the testing and employed three types of information - item difficulties, discrimination indices and pattern of responses to the various distracters - to improve the test. Content validity of the twenty item test was established by five science specialists who designed the instrument. Reliability of the test was estimated by using the Cronbach Alpha procedure. The Cronbach Alpha coefficient was 0.87 showing that the test instrument was satisfactorily reliable. The Cattell "Culture Fair" Intelligence test was administered to all the students in this study to see whether randomness was achieved in the assignment of the subjects to the
four treatment groups. The Keller Instructional Materials Motivation Scale [Keller 1987] is a 35 item, Likert-type instrument, which was developed to measure the presence or absence of the motivational components of attention, relevance, confidence and satisfaction in instructional materials. The validity of the instrument has been established by a study by [Keller, Subhiyah and Price 1989]. The internal consistency reliability of the instrument is 0.89. The instrument was translated into Malay language by the researchers and tested. The internal consistency reliability coefficient was 0.81. The Group Embedded Figures Test is a group administered test to measure the disembedding dimension of field dependence-independence). It involves disembedding 18 simple figures from a complex pattern or field. The reliability of the test was 0.82. The GEFT average was 12 and 10.8 for males and females, respectively [Witkin, Oltman, Raskin and Karp 1971].

**Procedure**

The treatment was administered by four instructors aided by two assistant researchers. All of them received instructions from the researchers on the experimental procedures prior to the data collection. Prior to the treatment the students were given the pretest, the Group Embedded Figures Test (GEFT) and the Cattell "Culture Fair" Intelligence Test. The instructors and their assistants were informed that the purpose of the data collection was for improvement of the student learning performance. The post-test were administered immediately after the treatment to measure the achievement of the students. This was followed by the Keller Instructional Materials Motivation Survey to evaluate their preference for the treatment.

**Results**

The first question being studied was to see whether that was any significance differences in learning gain amongst the various instructional modes. This was put in the following null hypothesis.

**Hypothesis 1:** There will be no significant differences in learning gains between the different types instructional modes.

An ANCOVA analysis [Table 1] revealed that the gain scores between the various instructional modes were significant, $(F, (1, 333) = 3.600, p < 0.05)$.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>1</td>
<td>0.587</td>
<td>0.333</td>
</tr>
<tr>
<td>Mode</td>
<td>3</td>
<td>17.131</td>
<td>3.600 *</td>
</tr>
<tr>
<td>GEFT</td>
<td>1</td>
<td>18.199</td>
<td>3.824</td>
</tr>
<tr>
<td>MODE x GEFT</td>
<td>3</td>
<td>4.562</td>
<td>0.959</td>
</tr>
</tbody>
</table>

[Table 1]: ANCOVA OF GAIN SCORE BY INSTRUCTIONAL MODE, COGNITIVE STYLE WITH I.Q AS COVARIATE

A t-test [Table 2] was carried out to compare the gain scores of the various instructional modes. In comparing the means of the gain score of students exposed to different modes of instruction, it was found that significant differences exist between Mode 1 and Mode 4 $(p < 0.05)$, between Mode 1 and Mode 3 $(p < 0.05)$. Since significant differences in learning gain existed between some of the instructional modes hence the null hypothesis was rejected.

<table>
<thead>
<tr>
<th>GAIN SCORE</th>
<th>N</th>
<th>Mean</th>
<th>s. d.</th>
<th>t value</th>
<th>d. o. f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1</td>
<td>87</td>
<td>5.3448</td>
<td>2.292</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode 2</td>
<td>81</td>
<td>4.7284</td>
<td>2.062</td>
<td>1.83</td>
<td>166</td>
</tr>
<tr>
<td>Mode 1</td>
<td>87</td>
<td>5.3448</td>
<td>2.292</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode 3</td>
<td>88</td>
<td>4.5909</td>
<td>2.267</td>
<td>2.19 *</td>
<td>173</td>
</tr>
<tr>
<td>Mode 1</td>
<td>87</td>
<td>5.3448</td>
<td>2.292</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The second question being studied was to see whether there was any significant interaction effect between the different modes of courseware and the cognitive style of the student? This was put in the following null hypothesis.

Hypothesis 2: There will be no significant interaction effect in learning gains between the types of instructional modes and students’ cognitive styles.

A three-way ANCOVA of the gain scores \( \text{Table 1} \) revealed that there were no significant differences in gain scores between the field dependent and field independent students. Thus results of the data analysis did not reject the null hypothesis.

The third question in the study designed to measure the motivation reaction of the students in the various instructional modes. It was formulated in the following null hypothesis:

Hypothesis 3: There will be no significant difference in the motivation reaction between the types of instructional modes as indicated by their responses on the Instructional Materials Motivation Scale (IMMS).

Date analysis from the means and standard deviation of motivation reaction of the students \( \text{Table 3} \) showed that there were some fluctuations in the motivation reactions with the students in Mode 1 obtained the highest motivation reaction scale.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mean</th>
<th>s. d.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1</td>
<td>140.60</td>
<td>16.88</td>
<td>87</td>
</tr>
<tr>
<td>Mode 2</td>
<td>134.85</td>
<td>12.92</td>
<td>81</td>
</tr>
<tr>
<td>Mode 3</td>
<td>134.09</td>
<td>14.51</td>
<td>88</td>
</tr>
<tr>
<td>Mode 4</td>
<td>130.71</td>
<td>18.58</td>
<td>77</td>
</tr>
</tbody>
</table>

Mode 1 = Graphics, Sound and Bullet-text  
Mode 2 = Graphics, No Sound and Plain-text  
Mode 3 = No Graphics, Sound and Bullet-text  
Mode 4 = Control experiment - Only Plain-text

A three-way ANCOVA \( \text{Table 4} \) revealed that there were significant differences by mode \( F(1, 333) = 5.749, p < 0.05 \) and hence the null hypothesis was rejected. Students exposed to an instructional mode 1 (Graphics, sound and bullet-text) obtained significantly higher motivation reaction compared to other instructional modes.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>4350.573</td>
<td>3</td>
<td>1450.191</td>
<td>5.749 *</td>
</tr>
<tr>
<td>GEFT</td>
<td>492.797</td>
<td>1</td>
<td>492.797</td>
<td>1.954</td>
</tr>
<tr>
<td>MODE x GEFT</td>
<td>295.760</td>
<td>3</td>
<td>98.587</td>
<td>.391</td>
</tr>
</tbody>
</table>
Discussion

There were several possible explanations for the results found in this study. The following sections present these reasons. Hypothesis 1 was proposed to find the relationship between learning gains between the different types of instructional modes. The result revealed that enhanced instructional mode on a computer-based learning environment with graphics, sound, and enhanced text had significant effects on the learning gains. This finding is consistent with studies by [Toh 1991], [Hannafin and Hopper 1989], [Dwyer 1978], and [Galitz 1981]. In Hannafin and Hopper's (1989) study, five functions of screen displays were identified: focusing attention, developing and maintaining interest, promoting deep processing, promoting engagement and facilitating navigation through the lesson. In Galitz's (1981) study, users were interviewed to determine desirable screen characteristics and desired screen characteristics included (a) an orderly, clean uncluttered appearance, (b) an obvious indication of what is being showed and what should be done with it, (c) information located where expected; (d) a clear indication of relationship between information on the screen; (d) a clear indication of options; (e) a clear indication of when an action could make a permanent change in operation.

In Toh's (1991) study, 389 students from 6 Malaysian schools, were either exposed to computer simulated experiments or hands-on laboratory experiments. It was found that students in the computer-simulated experiments group obtained significantly better gain scores compared to the "hands-on" laboratory group. Thus we can safely generalize that instructions through computer if properly chosen and appropriately presented, can add substantially to learning.

The results of Hypothesis 2 showed that there were differences in learning gains between field dependent and field independent students using the various modes of instructions. Field independent students generally obtained higher learning gains in all the four modes of instruction. The findings also support the argument that field dependent students are provided with an enhanced mode of instruction, their achievement tend to improve. Although the differences in learning gains in this study had not reach the level of significance, the results clearly show that there is a interaction between the cognitive style and the type of instructional treatment. This finding confirmed previous research that there were correlations of general ability and field dependence-independence with achievement [Ng 1981]; [Burwell 1991]. An alternative explanation for the performance differences noted by [Dwyer and Moore 1992] was the possibility that the field dependent subjects might have lower academic potential than the field independent students.

The assumption of Hypothesis 3 was that there will be significant interaction effect in motivation between the types of instructional modes. The results of this study revealed that significant differences exist in students' motivation from the various instructional modes. Students from the enhanced mode of instruction showed the highest level of motivation. This study is consistent with studies by [Abdul Rahim 1990]. A possible explanation for this finding is that according to [Keller (1987)], motivation to learn is affected by personal factors (attention, relevance, confidence and satisfaction) and environmental factors (such as the instructional mode). The environment inputs can mitigate personal input inadequacies in the learner's motivational status.

Instructional conditions that capitalize on the preferences of the field dependent students and challenge field independent students are more likely to enhance learning. These include offering deliberate instructional support with salient cues, especially organizational cues such as advanced organizers; providing clear, explicit direction and the maximum amount of guidance; providing extensive feedback; advising learner instructional support needed (examples, practice items, tools) and embedding questions throughout learning and providing deductive and procedural instructional sequence.

Conclusions

The information provided from the results of the study has several implications for the instructional designer.
Firstly it reinforces the notion that graphics and sound assist comprehension by helping the learning in organizing and chunking information. They provide information in a different mode than verbal text and as such afford an alternative mode for learning. Visual can supplement verbal information as well as present information that is difficult, if not impossible to present verbally. Secondly, it shows that computer-based instruction is a viable means for individualizing instruction when taking into consideration the many characteristics of the learner. Thirdly, it demonstrates that all learners do not approach the learning situation in the same way and that learners process their own learning in a variety of different ways. Further replication of this study is recommended to explore the findings described here, specifically in relation to interaction between cognitive effects, motivation and cognitive styles of users across different population and with larger sample sizes.

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Acknowledgements

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The Metaphoric Hammer: Driving Messages Home Through the Use of Metaphor in an EPSS

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Abstract: The user interface is the link between the human user and the information contained within a computerized system. It guides the user through any number of tasks. It provides a means for the user to access information rapidly, with a minimum of effort. It should, in a manner of speaking, make the user forget, if only for a brief period of time, that a machine is being used. In short, the user interface functions as an extension of self. This article chronicles the evolution of an Electronic Performance Support System (EPSS) for Industry Canada employees, and more specifically the metaphor selected as the extension of self.

Introduction

Software manufacturers are beginning to realize that the user interface is the key to a successful computer-based system. All too often, users have shied away from computers because of the cumbersome and unfriendly nature of the software tools housed within, despite their ever-growing capabilities.

Regardless of how much intelligence is built into a system, that intelligence is lost if the system is not used. When a user initiates a system, the first thing seen is the interface. The intelligence built into the system is not immediately apparent, and thus the user is initially unaware of it. If a user is not attracted to an interface, for any of a variety of reasons, the system will not be used. The selection and implementation of a well-grounded metaphor can go a long way to guaranteeing success. It is, in effect, the key in the door, and manufacturers are beginning to turn it.

A Brief Discussion on Metaphors

Metaphor is probably the single most used device for transmitting ideas between individuals. It allows the individual to communicate an abstract idea by creating an image grounded in reality. The metaphor’s strength lies in its ability to “point up dissimilarities and contrasts between two objects while simultaneously demonstrating that there are considerable similarities between the objects being compared” [Kendall & Kendall 93], [Lakoff 87a], [Johnson 94], [Halskov 94], [Erickson 95]. For example, one who fights vigorously ‘fights like a tiger.’ Similarly, one who seeks a peaceful solution to a problem is portrayed as a ‘dove.’ The tiger conjures images of ferociousness, while the dove conjures images of passivity. The use of metaphor allows the listener to ‘see’ a subject ‘through different eyes’ [Kendall & Kendall 93]. Metaphor provides a structure through which reasoning can be effected [Lakoff 87a].

Metaphor as Performance Support Facilitator
We bathe in an ocean of information, few would deny that. The difference between sinking, swimming and making port lays in one’s capacity to navigate across that ocean. But what is the ocean made of? What vessel does one use to traverse the deep waters? How treacherous are the waters? And how reliable is the vessel?

The answers:

- The ocean is composed of all the obstacles one faces in the day-to-day realization of one’s tasks. Those tasks may vary from the physical to the cognitive.
- The vessel is the tool used to perform a task. That tool takes on the characteristics of the metaphor which defines it. For example, one associates a hammer with power, and thus the nail is driven into the board. One associates the written word with communication, and thus ideas are transmitted [Lakoff 87b].
- The treacherousness of the waters is wholly dependent on one’s ability to accomplish one’s task.
- The vessel is as reliable as the metaphor. If the metaphor fails, the vessel sinks.

One may ask: “What does all this have to do with Electronic Performance Support Systems (EPSS).” The answer lays in the definition of an EPSS. That definition is basically the following:

A performance support system is a computerized system that integrates different technologies with the goal of improving the performance of the user by offering support:
- at the worksite
- when it is wanted and needed
- in the form that is most useful
- in operational mode or simulation of operational mode.

The role of a PSS is to advise, inform and teach [Dalkir et al. 94].

The key words in this definition, and the ultimate goal of any EPSS, are “improving the performance of the user.” These objectives cannot be met if the user has vague or incorrect notions on the what, when, where, why and how of the EPSS. A solid user interface metaphor, one that is able to “…shorten the distance between a user’s thoughts about a task and the system actions necessary to accomplish the task” [Nardi & Zarmer 93] can go a long way in contributing to the success of an EPSS project.

The IC Orientation Project and the Evolution of a Metaphor

Where is the life we have lost living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?[Eliot n.a.]

The goal of the IC Orientation Project was to provide Industry Canada employees with on-demand, computer-based, career-relevant information within an EPSS framework. The information contained within the product is of a generic nature. That is, its content is Industry Canada-specific rather than department-specific.

Prior to the project’s inception, Industry Canada employees were issued paper-based information packages which outlined employees’ basic rights, duties and obligations. These information packages were complemented by a two day orientation session. Though employees welcomed the orientation session as an opportunity to network, few claimed any other actual benefit. The reasons most often cited were the sheer volume of information delivered and the ineffectiveness of those presenting information. Ineffectiveness was primarily attributed to the relatively dry nature of the information.

Identification of User Problem

Though the employer had hoped that new employees would use the two day orientation session to learn about internal policies and the day to day functions of the Civil Service, employees came away with little or no knowledge. This was confirmed via interviews conducted among focus groups composed of a wide spectrum of Industry Canada employees.
Part of the problem can be attributed to the differences between orientation and training. In most cases, training requires employees be able to reproduce results intrinsic to the task at hand. Orientation is akin to acclimation—introducing workers to the global working environment and providing pointers to information which may be useful, when the need for that information arises: Just-In-Time. Orientation and training, however, are not mutually exclusive. Orientation can be viewed as a method of supplying minimalist training. Its activities can be developed around allowing workers to become immediately productive by reducing time spent on reading and other passive activities [Wilson et al. 93].

Orientation may serve as a minimum information roadmap, providing a starting point for further excursions into detailed information. The goal of this project was information provision, in the sense of a preparatory minimalist training, as opposed to instruction.

Nature of the Problem

In this description, we take into account workers’ extrinsic tasks and intrinsic tasks [Carr 92]. Fundamentally, we view the usage of an EPSS as support for the employee's extrinsic tasks. This had important implications on design, since users indicated they want to ‘be oriented’ to the point of performing their secondary extrinsic tasks in an efficient, a correct, and a time-saving manner.

Various types of employees—regular employees, managers and supervisors, human resources employees and service providers—have various concerns. Those concerns are guided by the nature of their role. Those roles are supported by either large volumes of paper-based information or cumbersome MS-DOS based applications. The problem therefore is shared by

- information consumers: Information consumers are the employees. They want initial overview information which scopes out the extent and location of available information. They also want rapid response to questions concerning work procedures.
- information producers: Information producers are responsible for developing and maintaining the policies and structures described in the paper-based orientation package. The clarification and explanation of such material, when it is not adequately distributed, may cause excess workload on the producers as they are asked to take on some of the information clarification work.
- information presenters: Information presenters are those who write and publish the communicated form of information as well as those who explain it in a general manner.
- information clarifiers: Information clarifiers are those who respond to specific content questions.

The EPSS, and its representative metaphor, therefore, had to be designed with the needs of all the above mentioned groups. The metaphor needed to not only assist in explaining those things of which the user had no knowledge, but also encourage exploration [West & Travis 91] in such a way that the user is unaware of a learning process. The metaphor had to organize and direct users’ cognition [Nardi & Zarmer 93].

Design Issues

Two metaphors were selected, each corresponding to two aspects of the product: orientation and reference. It was felt that the dual nature of the tool was best represented in this fashion [Johnson 94]. Selection was guided by the following considerations, aimed at the information consumer category of users described above. General constraints are described, followed by constraints applicable to the orientation and reference sections.

General
- The tone should be professional.
- The metaphor should allow navigational flexibility.
- Users want the flexibility of consulting materials of most interest.
- The metaphor should be realizable.
- The end result should be modular and modifiable to support future revisions.
- Maintain sufficient consistency between the metaphors selected for orientation and reference.

Orientation
The product welcomes new employees to their workplace and organization. The presentation should be “interesting” since the task is relationship building.

Reference
- The structure of existing paper-based documents should be accessible.
- The reference section should support the user reading a logical section of text.
- The reference section should support the user browsing information.
- The reference section should support the user information searches, particularly for the task of solving an identified problem.

Metaphor Generation and Selection

The use of metaphor originates in written discourse. It is one device, along with others such as simile and analogy, to draw attention to characteristics of a known concept, in our case travel, and a new concept, in our case, orientation information. The known and new concepts are referred to as the vehicle and topic respectively [Fainsilber & Kogan 84]. For user interface design, we are interested in the use of the visual aspects of a metaphor to convey its message. Imagery is often associated with metaphor [Ortony 75]. To effectively convey this imagery for our project, a graphic artist constructed the graphic elements critical to the communication of the metaphor.

Metaphor selection for the IC Orientation Project emanated from formal and informal focus group communications. These communications took on the form of formal questionnaires and informal brainstorming sessions which allowed potential users to describe the orientation experience [Kendall & Kendall 93]. The resulting metaphors, tour and book, fall into the categories established by [Kendall & Kendall 93]. The association between tour and journey is evident and needs no explanation here. However, the book-machine connection may lack clarity. If one relies on the machine metaphor attributes outlined by [Kendall & Kendall 93], then the link becomes more apparent. A book has a goal, start at page X and read to page Y. Its environment is such that to extract meaning one must follow a prescribed order of reading. And the leader is the book’s author, or designer. One may also be able to extract other metaphoric levels from the developed product, however those levels were never directly fostered.

Orientation

The travel metaphor was selected since it is associated with discovery of interesting attractions by a tourist with a positive attitude towards learning. An animation character is positioned in a scene which contains signs, background scenery, a road, and a billboard (see Figure 1). Each of these elements has metaphoric qualities. The signs correspond to information choices, the scenery to logical groupings of information, the road to semantic distance between information, as well as logical sequencing of information, and the billboard corresponds to overview information which serves to inform the traveler of the highlights of available sites. The character represents either a traveling companion, or the user as an extension of self. The character’s activities correspond to user tasks:

- the character standing under the signs is a metaphor for making an information selection decision;
- the character walking is a metaphor for the information browsing process;
- selecting a road to travel on and walking the full length of the road is a metaphor for a “distant jump” type of navigation [Gall & Hannafin 94]. We could consider selecting a site on a particular road as a “medium jump” navigation;
- walking partly down the road to look at the billboard is a metaphor for a an “adjacent jump” type of navigation [Gall & Hannafin 94];
- walking to the right is a metaphor for progressing towards one’s selected information goals;
- walking to the left, and returning to the home road, is a metaphor for returning to a point of information selection decisioning;
- the character stopping, turning, and reading the billboard is a metaphor for the focus of the reader’s attention on the new information becoming available.
Reference

The book metaphor (see Figure 2) was selected since it is associated with the more formal activity of finding and reading information. A dynamic graphic bookmark is used to indicate the currently selected book on the stack. As with actual books, a left and right page are visible at one time, and the book is prefaced with a table of contents.

Metaphor Evaluation

The development of the metaphors described here was a result of a series of prototype development and formative evaluation stages. The first prototype included only a book, but users did not believe it was appropriate for orientation purposes. The book metaphor was elaborated by adding page corners for navigation, a table of contents instead of a menu structure, and a bookstack instead of folders. In this way, the metaphor evolved into a more consistent and meaningful form.

A checklist metaphor for the tour was considered, but rejected because it was considered too formal for orientation purposes. Several intermediate tour road representations were considered:

- a winding road was found to be more realistic than a straight one, but too difficult to navigate and implement,
- a vertical road was also considered as more realistic in conveying the idea of motion, but also was difficult to implement in terms of animation,
- a multi-level road was effective at presenting a large number of selections at once. This approach was closer to a map metaphor and led to screen clutter which contravened the goal of an easy-to-use introduction to information.
- The final form of the tour metaphor was found to be an appropriate balance of navigation simplicity and flexible information access.

Conclusion

This article treated the evolution of a metaphor and its usefulness as a communicative device in Electronic Performance Support Systems. Although in some technical domains, the use of metaphor has been found to be limiting in its explanatory power [Nardi & Zarmer 93], we believe that in other applications, for example, orientation of new employees metaphor can quickly situate the user within a familiar context. Metaphor can thereby serve as a bridging device [West & Travis 91] when selected judiciously.

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[Eliot n.a.] Eliot, T.S. Choruses of the Rock I
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Assessing the Usability and Effectiveness of a Remote Language Teaching System

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Abstract: Distance learning is moving increasingly towards the use of computer technology as a means for distributing courseware, for demonstrations, and for asynchronous collaboration and discussion between students and tutors. Within a short time, however, the ability to communicate in real time using computers will exist for everyone. Multimedia conferencing over the Internet, using live audio, video and shared workspace, has until recently been restricted to the research domain. This paper describes a study in which this technology was used in a remote language teaching application. Small group tutorials were held over a number of months, in which students and tutors of foreign languages were separated by distance, but not by time. The paper discusses the evaluation issues and observations from these trials.

1 Introduction

The ReLaTe (Remote Language Teaching over SuperJANET) project is a remote language teaching application which uses multicast multimedia conferencing technology over the Mbone (Multicast Backbone)[Buckett et al., 1995]. It is a joint project between University College London and the University of Exeter, and is funded by British Telecom as part of the BT/JISC SuperJANET research initiative. The project has developed a demonstrator system which supports remote interactive language tutoring by adapting and enhancing existing multimedia conferencing technology piloted by the MICE (Multimedia Integrated Conferencing for Europe) project [Handley et al., 1993; Sasse & Bennett, 1995]. Prototypes of this demonstrator system were used in preliminary French teaching trials between the two partner sites during the course of July and August 1995, and more extensive trials were carried out using other languages between October and December 1995. Evaluation of this demonstrator system has two angles, the first looking at how easy the technology is to use, and the second looking at what aspects of language teaching can be engaged in successfully over the system.

This paper describes the methods employed in evaluating the system, and discusses the results of the study.

2 Components of Multimedia Conferencing

Multimedia conferencing technology has three main components: audio, video and shared workspace. The individual’s workstation has a camera mounted on it, and the participant uses a microphone and loudspeaker or a headset in order to speak and hear. It is usual practice to have to position the mouse in the audio tool window and hold down the mouse button throughout the duration of speech (a function known as push-to-talk). Likewise in order to use the shared workspace the mouse must be placed in the relevant window and clicked in order to be able to start writing. The shared workspace can be likened to a whiteboard on the computer screen. Whatever is written on the board can be seen and added to by all the participants. It is possible to import files onto this whiteboard and print the material out.

Use of these tools in multimedia, multiway conferences has brought to light important usability issues. Information is sent over the Internet in small packets. These packets can get ‘lost’ due to congestion on the net, or arrive out of order, rendering them all but useless. There is no way to guarantee adequate bandwidth at a certain time, and so loss of information is always a danger. Of the three streams of data that are sent during conferences, audio, video and shared workspace, experiences in the MICE project have shown that good audio quality is critical for effective communication to occur. [Sasse et al., 1994]. Audio that is subject to loss can be very disruptive (with lower loss rates the audio sounds bubbly, but as the loss rate increases, parts of words get lost), and some methods for compensating for this loss are better than others [Hardman et al., 1995]. However, there is a trade-off between method of repair and processing power required. Experimental work [Hardman et al., 1995] has pro-
duced some interesting results, but the conclusions drawn have yet to be assessed in a proper application. A new audio tool is under development in the ReLaTe project, and its performance will be assessed in future trials.

Synchronisation of the audio and video streams, in order to synchronise words and lip movements, is extremely difficult. One major reason for this is that real-time video places huge demands on the processing power of the workstation (audio is less processor intensive), which increases incrementally according to the number of video streams being received. It is common practice to send video at a speed of two or three frames per second (television quality is 25 frames per second). It is obviously meaningless to synchronise audio with video that is updated so infrequently. The video is perceived as being a point of reference rather than an aid to speech communication. Of course, in an application such as language teaching, it is anticipated that there will be much greater need for good, synchronised audio and video. The first implementation of lip synchronisation over the Internet, which works by delaying either the audio or video, is under development in the ReLaTe project.

3 Components of the ReLaTe Application

The tools that were used in the ReLaTe trials were the audio tool RAT [Hardman & Kouvelas, 1996] (which replaced vat [Jacobson, 1992] after the initial trials), the video tool vic [Jacobson, 1994], and the shared workspace tool wb [Jacobson, 1993]. The project modified the front-end of vic so that a single video window replaced the individual images which appear in the original version of vic. This single video window can display one large image and three smaller ones. The user can decide which of the participants should be in the larger window by clicking on the name bar above the participant. The user interface is shown [Fig. 1] below.

![Figure 1: The ReLaTe user interface](image)

4 The ReLaTe Application

The immediate aims of the ReLaTe project were to provide a working demonstrator of a remote language teaching application. It was hoped that the demonstrator system would show that the ReLaTe concept is a viable means of carrying out aspects of language teaching, and that the system has the potential to be developed further in order to share language teaching resources between academic institutions. It was not an assumption that remote language teaching will lead to more effective teaching/learning than the traditional classroom based methods, but it was desirable to show that the method does not produce significantly worse learning than face-to-face methods. As observed by one author [Laurillard, 1993], “Teleconferencing is essentially a solution to a logistical
problem, rather than a pedagogical problem, normally used to overcome the problem of communicating with students who are geographically distributed”.

The main objective for the trials was to gain an understanding of where the technology failed in the goal of language teaching/learning, and whether this failure could be remedied for future users.

5 Evaluating the System

There are two distinct aspects of the ReLaTe system that needed to be taken into account in the evaluation: the effects of the technology and network conditions and the pedagogical effectiveness. Questions that needed to be addressed with respect to the first aspect included: is the interface designed to enhance usability and is it intuitive to use? Do the users find the audio difficult to understand? Does having to manipulate the mouse affect the smoothness of the lesson? With respect to the second aspect, the pedagogical effectiveness, issues that needed to be looked at included: how does the ability of students learning with this system compare with that of subjects learning in the traditional way? How do users (teachers and students) find teaching and learning in this manner?

Conventional evaluative methods in the human factors and psychological literature include questionnaires, interviews, participant observation, content analysis and empirical experimentation. However, multimedia conferencing is a new area of research and development, and little research has been carried out on evaluation methods for this area. The evaluations that have taken place have tended to focus on the technology employed e.g. which encoder and decoders are used, rather than the users’ performance with and perceptions of the system. There has been very little quantitative or qualitative analysis carried out using subjects and experimental techniques, although some informal evaluation of experiences has been reported, for example, on the MICE seminars [Sasse et al., 1994].

6 Pedagogical Evaluation

It was recognised that the ReLaTe project needs to work closely with methods of evaluating new technology in education. How has evaluation of new technology in learning been carried out? [Laurillard, 1993] reports “New technology methods are too frequently introduced to students on an experimental, pilot basis without being properly integrated into their teaching. Students therefore see them as peripheral to the real teaching, and invest less effort in them than they otherwise would”. Therefore the more favoured evaluation methods have not tended to be controlled experimental approaches - the technology has been introduced into real courses and evaluated over long periods of time, often years. This also helps counteract the steep learning curve that can be associated with the introduction of new technology. This is in keeping with the opinion in the education field that conclusions from evaluation of the pedagogical effectiveness of new technologies in learning can only be valid if the technology has become part of the normal course conditions. The approach requires integration with other teaching methods and assessment.

Unfortunately, this approach was not viable due to the time constraints of the project. However, a literature search did result in some useful evaluative methods being identified. In their discussion of evaluation of CALL programs, [Scholfield & Ypsiladis, 1992] discuss a method whereby the teacher/researcher relies on personal introspection, and makes use of a checklist of evaluation points. A similar approach has been termed ‘impressionistic judgement’ [Thomas, 1994], and was used in our evaluation.

An evaluation plan was devised, whereby students would be taught by tutors at remote locations over a course of lessons. Each participant sat at a UNIX workstation (a Silicon Graphics Indy) equipped with a headset and a camera. Two or three students were involved per lesson. The trial details are shown in [Tab. 1]. Evaluation of the pedagogical and technological issues of the lessons took place through the techniques of observation, questionnaires, rating scales, informal interviews, expert evaluation and comparison with face-to-face classes.

7 Results/Observations

The results of the trials were gathered via observation by technical/HCI experts, language teachers as expert observers, questionnaires and rating scales completed after each lesson (in the earliest trials), and questionnaires and group discussions after the second set of trials. The results are presented below, considering first the multimedia conference components of audio, video and shared workspace with respect to a language teaching application [Tab. 2], and then discussing the pedagogical viewpoints collected from the end users [Tab. 3].
Table 1: ReLaTe trials scenario

<table>
<thead>
<tr>
<th>Trial Period</th>
<th>Language Course</th>
<th>Tutor Location</th>
<th>Student Location</th>
<th>Expert Observer</th>
<th>Number of Lessons</th>
<th>Duration of Lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>July-Aug '95</td>
<td>Intermediate French</td>
<td>UCL</td>
<td>Exeter</td>
<td>Exeter</td>
<td>6</td>
<td>1 hour</td>
</tr>
<tr>
<td>July-Aug '95</td>
<td>Intermediate French</td>
<td>Exeter</td>
<td>UCL</td>
<td>UCL</td>
<td>6</td>
<td>1 hour</td>
</tr>
<tr>
<td>Oct-Dec '95</td>
<td>Advanced French</td>
<td>UCL</td>
<td>Exeter</td>
<td>Exeter</td>
<td>10</td>
<td>2 hours</td>
</tr>
<tr>
<td>Oct-Dec '95</td>
<td>Business French</td>
<td>UCL</td>
<td>Exeter</td>
<td>Exeter</td>
<td>10</td>
<td>2 hours</td>
</tr>
<tr>
<td>Oct-Dec '95</td>
<td>Latin</td>
<td>UCL</td>
<td>Exeter</td>
<td>Exeter</td>
<td>10</td>
<td>1 hour</td>
</tr>
<tr>
<td>Oct-Dec '95</td>
<td>Beginner Portuguese</td>
<td>Exeter</td>
<td>UCL</td>
<td>UCL</td>
<td>10</td>
<td>2 hours</td>
</tr>
</tbody>
</table>

Table 2: ReLaTe trials - key observations and results

<table>
<thead>
<tr>
<th>Component</th>
<th>Observation</th>
<th>Comment</th>
</tr>
</thead>
</table>
| Audio     | 1. Push-to-talk problematic  
2. Fluctuating audio quality | 1. Abandoned in favour of full duplex  
2. Methods of repair under development |
| Video     | 1. Very slow frame rate  
2. Psychologically important | 1. Audio-video synchronisation under development |
| Whiteboard| 1. Does not function as word processor  
2. Mouse problems - ‘phantom click’  
3. Relied on heavily | 1. Shared text editor can now be used  
2. Specific to SGI workstations  
3. Interactive work domain appreciated |

7.1 Audio

The first major audio issue to emerge from the trials was that the ‘push-to-talk’ requirement did not enable satisfactory communication between the lesson participants. Having to place the mouse in the audio tool disrupted the lesson in three ways. Firstly, the phatic function was interrupted, and paraverbal (mmm, uuhh etc.) assurance was lost since only one participant could be heard at once. This was felt to be especially detrimental in a language teaching environment, where it can be expected that students will be more reluctant to speak in the target language without encouragement from the teacher. Secondly, since audio could only be transmitted when the mouse was placed in the audio tool area of the screen, when a participant switched from speaking to using the mouse in another part of the screen, other participants could be left unsure as to the cause of the ensuing silence - loss of audio connection with that person (system error), or side-effect of using another tool? Thirdly, it was observed that having to locate the mouse and place it on the audio tool meant that the participant did not maintain as much visual contact via the camera as desirable.

Once push-to-talk was abandoned, audio quality was the most frequently cited cause of dissatisfaction with the system. The problems seemed to be entirely due to the network conditions i.e. packet loss, rather than to background noise levels or volume differences between sites. It was the unpredictability of the sound quality that led to frustration - the quality could fluctuate dramatically within the course of one lesson. However, despite this fluctuation in quality, most of the participants said that they felt that they could rate the overall quality of the sound during the lesson. The results gathered from five-point rating scales indicated that most lessons were perceived as having fair or good quality audio. However, this result may reflect the overall enthusiasm of the students participating. There was a noticeable trend within some subjects to rate the audio quality as better towards the end of their sessions while the objective packet loss statistics suggested that this was not so. This suggests
that tolerance to poor audio quality increased as the subject became more familiar with the system and its inherent drawbacks.

7.2 Video

The main results concerning the use of video was that the frame rate was not fast enough to permit synchronisation, and as a result, it was not possible to use lip-movement as an aid to comprehension. However, one subject managed to find merit in the situation, commenting: “Tutor’s lip movement was delayed and didn’t match speech. Actually encouraged me to listen harder to the French sounds - very useful”.

The video images were made use of in many other ways, however, and was felt to be a valuable component. The other uses included as means of checking whether the other participant was speaking when there seemed to be an unusually long silence, indicating an audio problem; as a means of ascertaining comprehension on the other participants’ part (through smiling, laughing, nodding etc.); as a means of common reference, for example when the tutor indicates which worksheet to look at by holding it in front of the camera; as a means of picking up some of the nonverbal gestures pertinent to the target language; and as a psychological reassurance that the other participants are actually there (lack of sidetone in the microphone contributes to the feeling that the system is ‘dead’).

7.3 Whiteboard

Much innovative use was made of the whiteboard tool. Teachers used it for many varied tasks, including fill in the gap exercises, verb conjugations, spelling, reading comprehension, writing and description exercises. The tutors often imported text or postscript files, and used pictures that had been scanned in previous to the lesson. The students seemed to greatly enjoy using the tool. As one of the tutors pointed out, the opportunity for students to use the whiteboard is not usually present in a face-to-face class since it is usually in the teacher’s domain.

However, some problems with the tool were brought to light. One unfortunate problem, specific to the workstations used in the project (SGIs), was what came to be termed the ‘phantom click’, whereby it often took 2 or 3 clicks of the mouse for it to register on wb. In addition, wb as a tool does not have the same functionality as a common word processing package: there is no cursor, no automatic carriage return, and it is not possible to delete or edit single words in an entered sentence. With respect to language teaching, it was unfortunate that there was no facility to type accents on text - participants often resorted to drawing them in after they had typed the text. Although all participants in the lesson can use wb simultaneously, it is not possible to delete what another participant has written. It is also not possible to see the other participants’ pointers, so any point of reference has to be drawn onto the screen. As a result of these problems, a recent development has been to offer a shared text editor (nt) [Handley, 1996] in addition to wb. nt will not replace wb completely because wb can cater for things that nt cannot e.g. drawing and importing scanned documents.

7.4 User and Expert Observer Viewpoints

In addition to questionnaires and discussions with the participants and expert observers individually, all the participants from the trials were brought together for a group discussion workshop at the end of the trials, the main results of which are summarised in [Tab 3].

In the opinions of the tutors, both teachers and expert observers, who participated in the trials, the system shows a great deal of potential, and in its present state is capable of being used to teach effectively the four main language skills: reading, writing, speaking and listening. The system is especially valuable in that these 4 skills can be practised simultaneously, which is not something that can be easily achieved in conventional teaching situations. Use of the whiteboard means that problems with grammar, spelling and syntax can be monitored constantly and corrected immediately. It was also possible to achieve a fine degree of textual analysis with wb, due to the fact that the size of the window permits only a certain amount of text to be visible at any one time, focusing attention. The students were of the general impression was that they spoke as least as much of the target language as they would normally in face-to-face lessons. The phatic function was increased, which was seen as a benefit.

Overall both the teachers and the students were very enthusiastic, and it was felt by the expert observers that the system produced at least ‘as good’ learning as can be achieved in a face-to-face class.

7.5 General Observations on Teaching/Learning Style

Lesson time can be saved if teaching material is prepared beforehand (entered by hand or scanned in) and imported at the correct time onto the whiteboard. Typing large chunks of text during the lesson can be time-consuming, especially if users are not touch typists. These issues are non-trivial since in order to avoid these problems a different type of teaching style would have to be adopted in which the teachers prepared the material in a digital form before the lesson, and likewise the students would ideally do their homework on disc.
The observations and results indicate that remote language teaching over the Mbone is feasible, despite some problems stemming from network characteristics (namely packet loss) and from existing software functionality. Both teachers and students enjoy using the system and find it a valuable educational tool.

Future work will look at the efficacy of a new audio tool encompassing redundancy to repair packet loss [Hardman et al., 1995]. Audio/video synchronisation will be implemented and the effects of this will be assessed.

### References


### Acknowledgements

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Educational Hypermedia Systems for the Earth Sciences: Students as Authors

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Abstract: To meet National education goals, the U.S. Geological Survey (USGS) is exploring new ways of communicating complex earth science topics to pre-collegiate students. The goal of a long-term research and development project conducted by the USGS is to assess the effectiveness of using hypermedia technology to teach earth science. From 1991-1994, the USGS conducted phase one of this research project. The objective was to design and implement prototype hypermedia educational systems aimed at middle school students (grades 6-9). Two prototypes were developed; the GeoMedia series includes modules on a variety of earth science topics. Project results show that students who participated in the case study conducted by the USGS are progressively more critical in their expectations of hypermedia educational systems. Student expectations for system functionality and digital data quality frequently exceeded the performance of the computers available to them. The project team also observed that active participation on the part of the student in creating hypermedia reports and presentations promoted understanding of the earth science topics that were taught.

Introduction

The most effective teachers in life are those who instill a sense of wonder in their students—whether about earth processes, the evolution of life, or the rise and fall of ancient civilizations. But, evoking a sense of wonder about the Earth is a challenge for educators particularly in light of the decline of science literacy in the United States. As environmental issues become more complex, a critical need exists for an informed citizenry who is capable of making decisions about finite earth resources, natural hazards, and planning for the 21st century. Recent studies of educational performance worldwide show that United States students are ranked near the bottom in science and mathematics [Rutherford & Ahlgren, 1990, p. vii]. Legislation known as Goals 2000: Educate America Act calls for assistance to States and local communities in meeting the President’s education goals one of which is aimed at establishing the United States as first in the world in math and science.

Study Background

From 1991-1994, the USGS conducted phase one of the research and development project. The objective of this phase of the project was to design and implement prototype hypermedia educational systems aimed at middle school students (grades 6-9). Two prototypes known as the GeoMedia series were developed for operation on Apple® Macintosh® computers. Macromedia® Director™ was used as the hypermedia authoring software. The GeoMedia series includes the following topics: water cycle, carbon cycle, greenhouse effect, measuring time and environmental change, earthquakes, and understanding maps.

In addition to developing the two prototypes, the project team focused on evaluating the effectiveness of hypermedia systems in teaching complex earth science topics. The evaluation component of the project was based on conducting (1) a survey by sending questionnaires to 3,000 educators, (2) student and teacher workshops, and (3) student focus groups. Results of the evaluation phase show that although GeoMedia increased interest in the earth sciences among students, operating robust hypermedia systems on minimally-configured computers posed problems for integrating high-resolution animations, imagery, video sequences, and sound [Ferrigno & Wiltshire, 1994, p. 203].

[1] Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.
During evaluation of the GeoMedia series, the USGS entered into a cooperative research and development agreement with InterNetwork Media, Inc., the industry partner that co-produced the prototype systems. The cooperative agreement calls for conducting research into computer science techniques that advance the design and deployment of hypermedia systems. In addition, the joint project team will develop methods for migrating from producing prototypes to publishing education products for mass-distribution that support the outreach campaign of the USGS.

The first planned product is a GeoMedia hybrid, which is an integration of the topics contained in the two prototypes. Evaluation comments from teachers and students have been used to improve the existing graphical user interface to facilitate navigating through the information. The GeoMedia hybrid is being replicated for operation in the Windows™ environment in addition to the Apple Macintosh suite of computers.

Concurrent with publishing the GeoMedia hybrid, the project team is developing a series of titles on natural hazards: volcanoes, earthquakes, and storms. The Earth Power series is intended to expand the hypermedia functionality to allow students to create their own hypermedia notebooks. The research focus is on designing a graphical user interface that is both transparent to the user and is further integrated with the content of the educational system.

**Audiences**

Throughout the project, the target audience for the hypermedia systems has been middle school students. The study team conducted four focus groups with approximately four to six students in each group during 1995. Students were randomly selected from school tour groups that visit the USGS learning center. The purpose of the focus groups was to stimulate a dialog between the students and the study team on software functionality, entertainment and learning value, and the price that students would pay for a multimedia product. During each focus group, a member of the project team showed students sample screens from the GeoMedia prototypes and the forthcoming Earth Power series. The study team also conducted a series of children’s workshops at the annual meeting of the Special Interest Group on Graphics (SIGGRAPH/SIGKids). During the 4-hour workshop, students learned to create multimedia reports using storyboard techniques.

Qualitative data obtained from the series of student focus groups and workshops indicate that expectations of features contained in a hypermedia system changed significantly during the course of the project. The effect of mass-media and the rapid expansion of the World Wide Web could be contributing to the higher expectations that students expressed regarding the features of educational hypermedia systems. Students indicated that the underlying rhythm and tempo of the prototypes were perceived as too slow. The expected characteristics include extensive use of digital video, 24-bit color imagery, 3-dimensional interactive animations, and compact-disc quality sounds. Similar results were found during a study conducted by the University of California at Berkeley to evaluate hypermedia techniques for teaching engineering design to college and junior high school students [Hsi & Agogino, 1993, p. 260].

Another discovery made as a result of the student workshops held at SIGGRAPH relates to the role of hypermedia technology within the learning process. Active participation on the part of the student to create hypermedia reports and presentations was directly correlated to understanding the earth science topics that were taught. Understanding of earth science information was reinforced when students were given the opportunity to create their own hypermedia report. Furthermore, creating a hypermedia report fostered collaboration and creativity among the students. Learning to develop a storyboard helped to reinforce the concepts relating to natural hazards and the effective organization of information. The integration of the earth sciences with creative writing and the visual arts resulted in a tangible product that the students could use again. At the end of the 4-hour workshops, all student teams were required to demonstrate their hypermedia report to their parents. The students were enthusiastic about the presentations and showed great pride in their work. Even students who were unwilling to record their voices for the audio segments of the multimedia report, effectively conducted oral presentations to their parents. However, more in-depth research must be conducted by the project team to determine the extent that visual literacy promotes the understanding of earth science concepts among middle school students [Couch, et al, 1993, p. 1].

The next phase of the project is to broaden the audience base to include the home market. Although the primary audience remains middle school students, the project team views the entire family as a potential learning group. Life-long learning is also a key element of the USGS strategic plan for outreach.
Graphical User Interface Design

The graphical user interface design factors have changed during the course of the project to accommodate the expansion of the audience to the home market and the change in student expectations. The metaphor for the Earth Power series on natural hazards is constructed around a spatially-referenced approach to the topics. Navigation through the system is facilitated by the use of a “personal data assistant” tool. The “personal data assistant” tool includes a notebook feature that allows students to (1) create hypermedia reports on natural hazards, (2) write fictional accounts that are stimulated by understanding earth science concepts, or (3) develop study guides to organize information [Fig. 1].

Figure 1: Sample screen design of notebook tool in the Earth Power series.

The goal in developing the Earth Power series is to design a graphical user interface that is engaging and allows students to construct their own interpretations of the value of earth science in their lives. Current studies in instructional design indicate if students are immersed in the topics, the result is an increased motivation to learn [Hedberg & Harper, 1995, p. 302].

Summary

The project team continues to design software that is in concert with national curriculum standards and reform movements, such as Project 2061 sponsored by the American Association for the Advancement of Science (AAAS). The AAAS emphasizes several key concepts for teaching science as part of the Project 2061 initiative. Among these principles of learning are two key philosophies embraced by the project team during the hypermedia design process: (1) do not separate knowing from finding out, and (2) science teaching should reflect scientific values—welcome curiosity, reward creativity, and encourage a spirit of healthy questioning [Rutherford & Ahlgren, 1990, p. 185].

Project results to date show that students who participated in the case study conducted by the USGS are progressively more critical in their expectations of hypermedia educational systems. The student expectations for system functionality and digital data quality frequently exceeded the computing capability available to them. The project team also observed that active participation on the part of the student in creating hypermedia reports and presentations promoted understanding of the earth science topics that were taught.

References
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Analyzing the Process of Learning in a Web Based Community of Learners

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Abstract: This paper presents and examines new methods for analyzing the process of learning in constructive and communicative Web Based Learning Environments (WBLE). Models of biological, sociological and physical complex systems are compared with the structure and the usage data of a Web Based Learning Environment. The paper focuses on the question how empirical data can be compared with simulated data from the models, and if the models can supply us with deeper insight in the learning processes of individuals and groups.

1. Introduction

The Internet not only starts to blur our conception of distance, it also frees the access to interactive media from specialized computer labs. Modems and networks make it possible to access the Internet at school and at the training center, at work and at home [Wolf 95]. Learners can use such systems at places and at times when they are ready for learning or in the need of it (as in just-in-time learning settings).

Web Based Learning Environments (WBLE) can support and facilitate communicative, cooperative and collaborative learning experiences, an area which traditional educational interactive media don’t support in general [Webb 95]. Additionally WBLE can also create constructivistic learning possibilities by enabling the learners to create their own contents and construct a personal meaningful structure of their own and other’s supplied information. Freeing the teacher from the content provider role gives them the opportunity to engage in activities such as learning coach or consultant, co-learner or scout [Kafai & Harel 91, Sembill & Pasch & Wolf & Wuttke 96].

From a research point of view the use of computers [MacLeod 92] and the World Wide Web makes it possible to dynamically log and analyze parts of the learning processes of students.

This paper concentrates on presenting and examining new methods and tools for analyzing the students’ process of learning for themselves, with others and for others. The guiding questions were:

• How do learners differ in their use of the WBLE?
• How do learners assimilate (= learn) information provided by others?
• How does the information space and it’s structure grows?
• How does the different usage styles influence the learning success?

2. The Web Based Learning Environment

The explorative data was created in a Web Based Virtual Campus (SoLe/W3), where students can (for a detailed description see [Wolf 95]):
- access and search for information
- create their own documents (provide information to others)
- construct their own links between documents (build up their own structure)
- communicate with each other
The Virtual Campus follows a place metaphor providing several buildings:

− a media center where the students can look at, search for and create hypermedia documents, hyperlinks and other kind of interactive media,
− a communication center with a blackboard, a post office, a discussion hall and a virtual café,
− an expo hall where students can display their work.

The Campus has been employed both at university and vocational training level on different themes in different learning settings (from computer only to computer as an option). The number of students ranged from 2 to 21. The students were encouraged to cooperate and collaborate in the projects.

Two versions of the system were used. The older version running at the vocational school has been realized in VisualBasic, the new version used at the university has been created in Webber, a development system for creating Net Based Learning Environments based on ScriptX from Apple and Java from Sun.

3. Tools for Usage Analysis

World Wide Web servers provide very detailed log files of the system’s use, recording the action of the users in a very fine grain (user, time, date, document accessed or scripts called). Data holes can result from the caching of the browser software, which holds documents in its memory for future reference. To avoid loosing track of the students navigation paths the campus’ documents forced a reload each time they were accessed.

Furthermore the documents of a World Wide Web server are written in plain ASCII-text using the Hypertext Markup Language (HTML). This allows an easy analysis of the structure of a website by reading the file contents and parsing the link structure.

For the data acquisition and descriptive visualization a Mathematica package has been developed (Lyza) which analyzes both the structure of a website and the learner’s usage.

In a first pass Lyza reads the files of the Web server and parses them for contained information about creation date, date of last change and links to other documents or scripts. In a second pass the program parses the log-file of the server.

![Figure 1: Visualization of document structure: (a) Color indicates date of creation (lower half) and change (upper half), links not shown; (b) Color indicates date of creation and change, links shown; (c) Vector field of Navigation: Color indicates how many times the links have been followed.](image)

The software creates a two dimensional lattice-graph of the network. The documents are displayed as squares. For all analysis it is possible to exclude users out of the data base, down to the individual learner. The documents are placed for display on a two-dimensional plane by minimizing link length and maximizing distance to other unlinked documents [Fig. 1(b)]. The documents can also be clustered by author, by keyword or manually. Because the virtual campus is a dynamic structure (the users are constantly adding documents and links), the
software saves the state of the system and can compare these different states resulting in an animation of the growth of the system. To use this feature in a meaningful sense, the graph is either only optimized for new documents, leaving the old documents at their place, or the graph is optimized for the last t(n), not displaying new documents added after the analysis date t(n-x). The color of the documents indicate either their age (upper half: age of last change, lower half: age of creation) [Fig. 1(a)] or the number of accesses. The color or the thickness of the edges denotes how many times these links were followed [Fig. 1(c)]. The contents of all documents can be accessed with a Web browser for quantitative analysis. Documents can be given attributes (such as deepness or width of content etc.) for multi-dimensional analysis.

To visualize the navigation of the users their paths can be overlaid, showing either the frequency or the order of the chosen paths. The system can also list the documents accessed by specific students in a certain time frame. This is very helpful for qualitative analysis of content assimilation. It also generates a list of the online-communication between students.

To gain insights in the learning processes of individuals and groups, the empirical structure and usage data has been visualized and compared with models of biological, sociological and physical complex systems [Gaylord & Wellin 95]. The results shall help in a further decision about the usefulness and the refinement of specific models as well as the formulation of hypotheses for future studies. The main questions of the quantitative analysis described in [Usage Strategies], [Creating Knowledge] and [Construction of Links] were

- how to compare the empirical data with the simulated data,
- and if one can identify or model structures in the use of the system.

4. Usage strategies

4.1 Random walks

Hyperlinked systems often create navigational problems for their users („lost in hyperspace“) [Dede & Palumbo 91]. Therefore usage paths of the users were compared to simulated random walks in the system calculating the mean square end-to-end distance and the mean square radius of gyration [Barber & Ninhan 70]. Different numbers of step locations (longer or shorter paths) were analyzed.

The usage path of the users differed from simulated random walks. This is expectable, because users had a certain task to accomplish. Nevertheless, some more explorative or confused parts of navigation could not be distinguished from random walks. Therefore phases of directedness and random navigation seem to be part of all navigation paths, although there are differences between learners.

4.2 Phase portraits

Analyzing the navigation path of a user in systems containing eighty up to several hundred documents over five up to forty hours and more asks for methods to find underlying structures of the data. To analyze the dynamics of usage, in other words to map the geometry of behavior, discrete phase portraits were created of each user, for clusters of users and the group [Packard & Crutchfield & Farmer & Shaw 80]. Two different state spaces were used:

- a state showing all links between documents:
  a point in this state describes the transition from document \(d_m\) at time \(t\) to document \(d_n\) at time \(t + \tau\)
- a state showing content specification of documents to a given starting document:
  a point in this state describes the transition from one content specification level \([1]\) at time \(t\) to another level at time \(t + \tau\).

[1] The content specification level is attributed to documents relative to the start document in a quantitative analysis.
(e.g.: Animals (0) - Mammals (1) - Dogs (2) - Poodles (3) - Flori, the Poodle (4)).
To get less noise in the graphs, pure interface pages (e.g. the entrance hall of the media center) and communication pages were taken out of the analysis. The communication pages were analyzed separately.

The phase portraits of content distances show quite clearly usage strategies such as „link-by-link“ [Fig. 2(a)], „search deep and jump back to start“ [Fig. 2(b)], „level for level“ [Fig. 2(c)] or „jumping around, then link-by-link“ [Fig. 2(d)]. Usage strategies toggled analogous to [Random Walks] between two or more types. There seem to be different navigation strategies between both learners and different phases of learning. Strategies used in a certain learning phase (e.g. exploration) from one student may be used by another student in a totally different learning phase (e.g. recap).

The transition phase portraits are more complex [see Figure 2(e - f)]. In the start they tend to be very similar, which is understandable because there are only a few documents and links. There seems to be a critical point in the development or the size of the network where the portraits start to differ. They become more and more independent of the link structure. Also the areas of interest show quite clearly. To identify attractors the usage paths have to be long enough in comparison to the size of the network, or the usage paths of several students have to be combined. Although the appearance of the transition phase portraits is very sensible to the numbering of the documents [Figure 2(e)] vs. [Figure 2(f)], their inner structure stays the same.

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Figure 2: Phase portraits of usage paths: (a)-(d) Axes denote the level of content specification. (e) - (f) Axes denote a unique number for every document. Both graphs show the same usage path with different numbering of the documents.

5. Creating Knowledge

To analyze the spread and „invasion“ of information from one user to the other, original documents (documents introducing a new topic) and follow-ups were filtered. These clusters were compared with a single percolation cluster model [Hermann 86] and an invasion percolation cluster model [Chayes & Chayes & Newman 85] using standard graph structure indicators [Freeman 78, White 85, Bonato 90, Skiena 90, Jungnickel 94].

The empirical networks could be classified in two kind of graphs. If the follow-ups were very much linked with the original, the graphs became very compact (focused threads). Themes leading quickly to other subjects became very clustered (open threads) [Fig. 3]. The single percolation cluster model (a variation of the Eden model) describes the epidemic spread of disease. It seems to create some comparable graphs with the appropriate parameters (infection probability of approximately 0.55 to 0.6 (focused thread) and 0.8 to 0.9 (open thread). The invasion percolation cluster model is used for the simulation of the flow of fluid through porous media. It therefore follows the path of least resistance. Using standard graph indexes percolation cluster models seem to be comparable to some of the original networks (open threads). This could reflect the students’ preferences for...
certain themes because they seem to be important, are interesting, promise some fun etc. For further comparison the order of creation should be considered (shown in different shades of grey in [Fig. 3]) as well.

Figure 3: Percolation clusters. (a) Invasion percolation cluster, (b)-(e) Single percolation clusters with infection probability = (b) 0.9, (c) 0.8, (d) 0.6, (e) 0.55.

Are students influenced by the themes and information their co-learners are presenting in the campus? A probabilistic Ising model was compared with the number of students working on the same theme. An Ising model describes the imitative behavior in which individuals modify their behavior so as to conform to the behavior of others [Callen & Shapero 74].

Only some short phases of imitative behavior could be observed. This may be due to the small number of students actually using the system (n<=8). Therefore further experiments with a greater n are needed. Also the goal of the studies were explicitly set as creating both a broad and deep discussion of the theme, resulting in some specialization. Another point is that the system does not yet support a MOO-setting, enabling to „see“ other users looking at this document or leaving through some hyperlink. This could support imitative behavior, too.

Does all themes prosper in the same way? Or do they develop in an episodic manner, bursting with activity for a certain time and stay unchanged for another period of time? The major themes were placed on a two-dimensional lattice graph. Heavily interconnected themes were placed near each other. Then the number of documents and the number of words contained in the documents were shown along the z-axis. These graphs were analyzed for clusters and compared with a co-evolution model [Bak & Sneppen 94].

According to the co-evolution model the development of themes should not be equal but should be unevenly distributed, building clusters of interrelated themes building up quickly, then stay stable. It becomes harder to evolve a well developed theme and therefore it becomes less probable. This behavior can be found in the data, but effects of diminishing returns or social imitations could explain this, too. The effect is very sensitive to the definition of themes due to the limited scope of the data space.

When are new themes approached? Does the structure (amount of data and links) of a certain themes reach meta-stable states, called self-organized critical states, where even small changes can result in chain reactions, leading to new themes tackled, new aspects seen etc.? Activities (creating documents, linking documents, reading documents) were clustered in theme-blocks and compared to a sandpile model [Bak 91].

So far no strong similarities could be found. Especially no self-organized critical states with a following chain reaction have been identified. Maybe these processes need a critical mass of users and data space. Also maybe the indicator (activities) was not rightly chosen.

6. Construction of Links

Enabling the users to create their own hyper structure of the data space should give us insight in their mental model of it, although already existing links prevent the students from explicitly creating an own link. Therefore maybe a combined approach of using links created and links used by a learner should represent the mental model. This was not done in this study.

While the students tend to integrate their own documents into their own structure, a question was if the other students integrate (make a link to) the work of others. Therefore all links between documents of the same author were ignored. Documents which no longer were connected to the network were eliminated. Then the density of
space occupied (a fractal dimension of the network) was calculated and compared to simulations of Diffusion-Limited Aggregation models [Sander 87].

Some problems emerged from this approach, because larger parts of the documents were not linked by non-authors and were eliminated. This lead to a density of space occupied being smaller than in the model. Also the DLA-model cannot model direct links between far away documents (a point in a DLA-model always have to be connected with at least one other point). Furthermore the author of a theme cluster often provides a reasonable link structure, therefore often there is no need for creating new link structures. More research with a greater data-space, some modified aggregation models and a multi-dimensional representation of the link structure is necessary to get more insight.

7. Conclusions

Constructive Web Based Learning Environments allow students to create and use their own and others mental models. These environments seem to be promising to collect fine grained data about learning processes. Integrating other interactive media such as simulations or tutorial systems under WWW allow to broaden the learning possibilities while retaining the tight data control. The data can be visualized, analyzed and compared with mathematical models of complex systems to gain a further understanding of underlying principles of individual and group learning.

For empirical valid results a study with a larger user base will be carried out this year. Additionally it will be necessary to evaluate and compare the learning outcomes (LO) of different types of learners. The identification of the individuals’ contribution to the knowledge space will make it possible to distinguish between LO of information provided by the student himself and LO of information provided by others. This could help in identifying the success of learning for oneself, from others, and for others.

The experience gained from these explorative studies seems to support the assumption, that learning processes can be modeled, but not predicted for the individual or for the group because they are probabilistic and very complex. It will be interesting to research if these underlying principles can aid the student’s learning, and how these principles can be supported or (if necessary) reduced by the design of learning environments or the intervention of the teacher.

8. References

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A Multimedia Authoring System for Building Intelligent Learning Systems

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Abstract: Intelligent learning systems usually involve complex strategies to help students learn a subject domain, possibly with simulated or human companions. The design and implementation of such systems rely much on the fascinating capabilities of multimedia authoring systems. Current authoring systems can connect non-sequential multimedia materials with hypertext links. However, they generally lack tools for viewing and editing the static organization of materials. Although some system can use a network model, which is intended for managing hypertext links, to organize materials, the management problem for dynamic navigation and the organization problem for static material structure should be treated independently. Based on this observation, we have designed and implemented an authoring system that provides tools for solving these two problems separately. Moreover, the system’s script language is LISP, which is suitable for implementing artificial intelligence models used in learning systems. The system is called GETMAS—Goal Episode Tree Multimedia Authoring System.

1 Introduction

Face-to-face instruction such as lecturing is an important means of transferring knowledge to students but it has some limitations. For example, the students might have different background and the lecture might not be useful for some excellent or poor students; it is difficult to demonstrate the simulation of some physical behavior because of its dynamic nature. Fortunately the technology of computer-aided learning can help solve some of these problems. In a well-designed computer-aided learning environment, a student can navigate the learning materials based on his needs. If he is familiar with a topic, he can skip it and jump to more interesting topics. The environment could allow the student to supply the values of some parameters and run a simulation whose process and results can be viewed on the monitor screen. If the environment has more intelligence, then the student’s misconceptions could be modeled and diagnosed. These design features are made accessible to educational professionals with the help of multimedia authoring systems. To understand the strength and weakness of some of the currently available technologies, we have studied several commercial authoring systems, including Macintosh’s HyperCard and SuperCard, Asymmetrix’s Multimedia ToolBook Version 3.0 for Windows, and Macromedia’s Authorware Professional 2.0 for Windows. To solve some of the problems which are not addressed by these tools, we have designed and implemented a multimedia authoring system called GETMAS.

2 Management of Hypertext Links

When we read a paper or a textbook, we often come across places which refer to other parts of the same text, or other texts. Such references are important for the reader to trace the origin of ideas or to confirm similar finding from other sources. The annoying part is that the reader might not have the references at hand or might find it troublesome to turn to the referred pages. Now the idea of hypertext offers a solution to these problems ([Conklin 87]). Hypertext is just an electronic form of the reference pointers like the ones in a hard copy paper, with the addition that the reference materials are available with a simple mouse click. For example, in using the on-line help manual of Windows on a PC, when we come across a specially marked hot word, we can jump to the reference materials simply by clicking the mouse at the hot word; when we browse a page on the World Wide Web, we can jump to another home page at a different site with a mouse click at a hot word.

Hypertext link is an important feature for a multimedia authoring system and all authoring systems we encounter have this feature. In order to implement an intelligent learning system which stresses personal and adaptive learning for students, hypertext link is a must. When the student is already familiar with a topic, she can choose to skip it by jumping to the next topic. When the student fails a test, she can choose to jump to review the topics...
that are subjects of the test. When there exist other human or simulated learning companions, the interaction protocol for all involved agents can be viewed as a set of navigation links—an agent would take certain action depending on the previous action taken by another agent and the current state of the interaction. Consider a learning environment where a tutor is monitoring the progress of a student, when the student poses a question, the tutor is obliged to respond to her. For examples of social learning systems, see [Chan et al. 96]. Thus, hypertext link is actually an implementation of one form of teaching strategies.

As a learning system gets larger, its teaching strategies can become quite complex and the management of navigation links is a serious problem for the designer of the system. The problem is worse if the teaching strategies are tentative and subject to revision based on the evaluation of learning effectiveness when the system is repeatedly tested and improved—which is often the case for many advanced prototype learning systems. For most authoring systems, the navigation links are specified in scripts that are attached to user-interface objects such as a push button in a window. Since the interface objects are scattered all over the system and the navigation code are embedded in scripts that might contain a lot of other information, this often produces "spaghetti networks" of information, similar to the use of the goto statement in early programming ([DeYoung 90]). As a result, it is difficult for the designer to keep track of all the navigation links and the teaching strategies they implement.

The authoring system Authorware offers a nice "visual" solution for managing the complexity of navigation links (e.g. see [Koegel & Heines 93]). When the designer is developing a learning system, she does so by constructing a visual network to model the navigation control of the system. A node in the network represents a unit of learning materials or a decision point where navigation to one of several destinations is triggered by the previous user input or system message. Authorware offers a number of node types for manipulating different types of media and for controlling navigation. To help manage the size of a network, Authorware allows a subnetwork to be abstracted as a node so it is easy for the designer to construct a subnetwork small enough to fit a single screen at each level of abstraction. Thus, at any point during the system development process, the designer can view the global shape of the network at different levels of details. This visualization helps the designer to understand the teaching strategies the system is currently using.

3 Management of Hierarchical Organization

We take it for granted that almost all text books are arranged hierarchically, with chapters, sections, subsections, paragraphs, etc. This indicates that when there is a large amount of information, a natural way to organize the information is to do so hierarchically. It helps the author to manage the organization when producing and organizing the learning materials. It also helps the reader to understand the global structure of the domain knowledge so as to locate the information the reader needs. When a designer develops a computer-aided learning system, it is important that she has tools to organize the learning materials hierarchically.

[Mayer et al. 93] solves this organization problem for ToolBook, which is an early version of Multimedia ToolBook, by automating the construction of a table of contents which lists the section titles that are specially marked in the learning materials. GETMAS solves this problem with an explicit representation of the hierarchical organization of the materials. First, the designer can understand the current organization by just looking at the developing hierarchy on a single screen. Second, a subtree can easily be removed from its parent and attached to another node. This makes development and reorganization much easier. We call this solution an editable representation of the material organization. No commercial authoring systems that we have studied offer such direct solution to this problem. However, Authorware can claim to solve this problem indirectly.

The previous section has described the network architecture of Authorware for modeling the navigation control of a learning system. The same network model can be used to organize the learning materials hierarchically. Each node can refer to a unit of learning materials and can have links to zero or more children nodes. Also, each subtree can be abstracted as a single node. In short, even though the network model of Authorware is intended for dynamic navigation control, the navigation network can be viewed as a static organization of the learning materials.

4 Pyramid Architecture for Material Navigation and Organization
Though Authorware’s navigation network can be constructed hierarchically and treated as an organization of the learning materials, we believe that such treatment is not natural. Since the learning materials form a subject domain, they can generally be grouped as a static hierarchy, like the chapters and sections in a common textbook. On the other hand, the teaching strategies that a designer uses are of a dynamic nature. For example, skipping of familiar topics, revision of unfamiliar topics, and communication protocol for learning companions are strategies that should be independent of the static organization of the learning materials. As a result, we believe that the dynamic navigation control and the static organization of learning materials should be treated independently. A similar argument can be found in [Stubenrauch et al 93]. In other words, a designer should be able to build the knowledge hierarchy of a subject domain and then design the navigation strategies to control how a student navigates through the hierarchy. It is this perspective that motivates the architecture of the multimedia authoring system that we have designed. The system is called GETMAS---Goal Episode Tree Multimedia Authoring System.

GETMAS provides a tool for the designer to organize the curriculum materials hierarchically. This hierarchy is called the goal tree (Figure 1b), which consists of a unique root node and other nodes. Each node has zero or more childen nodes. The child-parent relation is graphically represented by a line linking the parent node to a child node below it. Each node is called a goal node, representing a learning goal for a student to achieve. Besides having children links, each goal node also has an episode node attached to it (Figure 1b). Each episode contains a number of cards attached to it. It is the cards that contain the learning materials, i.e., texts and other multimedia resources, to be displayed to the students. In this way, an episode groups together a small collection of closely related learning materials.

Figure 1: An GETMAS applications architecture

Figure 2 shows the goal tree of a multimedia demo application. It has a root node whose unique ID is 200. It has four children nodes, each of which has a card to demonstrate different multimedia capabilities of GETMAS.

Figure 2: The goal tree of a demo application

GETMAS provides a dialog box to let the designer do several things to a goal node. First, she can add and delete children nodes of the goal node. Second, she can browse the episode cards under the goal node. Finally, she can edit the script of the node to control its behavior, including possible transition from its episode to another episode of another node.

The architecture of an GETMAS application can be depicted vividly as a pyramid (Figure 3). The upper part is the goal tree which organizes the learning materials while the bottom layer is a collection of episodes with hypertext links which implement the teaching strategies. There are two types of hypertext links in GETMAS: links connecting episodes (episode links) and links connecting cards (card links) in an episode. No links are allowed to connect a card of an episode to another card of a different episode. This is consistent with the organization principle that closely related learning materials are grouped under a single episode. Moreover, transition between episodes can be made via episode links.
Since the cards under an episode are closely related in their contents and there are usually a small number of cards under a single episode, the links among cards are often quite simple, with transitions like next, previous, first, and last. In contrast, episode transitions are used to implement teaching strategies, which can be very complicated. Therefore, a design decision is made in GETMAS that a single centralized episode transition table is used to store all the transitions among episodes. This is important because a centralized transition table presents a clear navigation map which helps explain the embedded teaching strategies. Since good teaching strategies can only result from repeated experimentation, it is important to provide a handy tool for viewing and editing the current strategies.

The origin of GETMAS' architecture can be traced back to the proposal of curriculum tree [Chan 92], which is a knowledge-based architecture for building intelligent tutoring systems. The non-leaf nodes of a curriculum tree are called scheduling nodes, which are similar to GETMAS' goal nodes, and the leaf nodes are called episode nodes. Each node contains rules about the domain knowledge and the protocol strategies for controlling navigation among the nodes and for coordinating actions of a student and other simulated agents. A node inherits rules from its ancestor nodes. An advantage of this inheritance is that rules need not be duplicated in every relevant node. On the other hand, a disadvantage is that the rules are scattered throughout the nodes and so are not as easily managed as the teaching strategies implemented with GETMAS' transition table.

5 AI Script Language

No commercial authoring systems that we know use a script language that is good for AI programming. This offers little help for people who want to design intelligent learning systems. Common AI techniques used in some classical learning systems are inferencing (e.g. SCHOLAR [Carbonell 70]), natural language processing (e.g. SOPHIE [Brown et al. 82]), tutoring heuristics (e.g. WHY [Steven et al. 78]), student model (e.g. GUIDON [Clancey 79]). They are usually implemented with LISP, Prolog, or other expert system shells or knowledge representation languages. Since AI programs are usually built as prototypes to demonstrate the feasibility of AI ideas and short development time is desired, languages such as Basic and C are not suitable for such purpose. Unfortunately, most authoring systems use script languages that are like Basic and so are not suitable for building intelligent learning systems. To solve this problem, GETMAS uses LISP as its script languages. This is a natural choice since GETMAS itself is coded with Macintosh Common Lisp and using LISP as its script language does not compromise the efficiency of the system. Though there is a myth that LISP is not an efficient language, the myth is not true---LISP can be as nearly efficient as C [Norvig 92] and GETMAS is almost as efficient as SuperCard according to our experience.

6 Sample Application

An example we have developed with an early version of GETMAS is known as Three's Company, which is an intelligent computer-assisted learning system with two simulated learning companions. When using the system, the user goes through three phases: introduction, test, and regular phases. During the introduction phase, the user watches a short video describing some achievements of the research of neural networks. In the test phase, the user is presented with five questions about the video. The system uses the results to set up the initial proficiency level of the user. If the user gives four or five correct answers, then the user's level is superior. Two
or three correct answers implies the mediocre level. Zero or one means inferior. Using this classification, the system sets up some initial attributes such as confidence and challenge for the student with rules such as the following two.

Rule 1:
If (user is superior)
then (user has high confidence & faces medium challenge).
If (user has high confidence & faces medium challenge)
then (increase challenge for user).
If (increase challenge for user)
then (increase companions' relative performance & make question more difficult).

Rule 2:
If (user is mediocre)
then (user has unknown confidence & faces unknown challenge).
If (user has unknown confidence)
then (increase confidence for user).
If (increase confidence for user)
then (make question easier).

The regular phase comes after the test phase. This phase will present six questions to the user. After the user answers each question, the learning companions will react in a way depending on the correctness of the user's answers. For example, if the user's number of correct answers is greater than that of a companion, the companion will answer the question correctly. Otherwise, the companion will use its past correctness rate to determine whether to answer correctly or incorrectly. More specifically, if its past correctness rate is 40%, then it will generate a random number between 1 and 100. If this number is less than 40, then it will give a correct answer. Otherwise, it will give an incorrect answer.

7 Discussion and Conclusion

In its current version, GETMAS has several limitations. First, its episode transition table would be difficult to read when there are many entries. Since the table is equivalent to a finite state transition automaton which in its graphical form is more intuitive, a natural improvement of GETMAS would be to show the table as a finite state transition diagram. Second, even though the navigation links are gathered at the transition table, the scripts that send messages for navigation control are scattered throughout the episodes. A better solution is to gather these transition-controlling scripts at a single script. This would increase the clarity and manageability of the teaching strategies implemented by the navigation links.

Finally, for an GETMAS application, the goal tree is embedded in the application and the tree is not used by any other application. In the future, we hope to let course designers share a single goal tree. This tree is constructed by domain experts who are knowledgeable with the domain. Courses are designed by instructors who are experienced in teaching classes. Depending on the background of the students and the depth of the course, a course designer can build two different learning systems using the same goal tree. For example, non-major students can skip some difficult topics that are needed only by advanced courses for major students; a graduate class can skip the nodes that undergraduates are supposed to know. Therefore, domain experts can build a wide and deep goal tree with GETMAS and store the tree as a file. Then a course designer can use GETMAS to retrieve the tree and build the navigation links for a specific class of students. In this way, domain knowledge can be centralized in a single tree instead of being duplicated by different applications that share the same domain knowledge. This would save efforts in building goal trees that share a lot of common topics.

We believe GETMAS is a versatile multimedia authoring system. Compared to other authoring systems, GETMAS has several outstanding features. First of all, it allows a hierarchical organization of the learning materials that does not limit the flexibility of navigation links for implementing the teaching strategies. Second, it provides a global episode transition table that helps the designer to keep track of the teaching strategies used in the application. This helps the designer to experiment and improve the strategies. Last but not the least, GETMAS uses LISP as both its system and script languages. Since LISP is a great tool for implementing AI techniques and for quick prototyping, GETMAS is a powerful and user-friendly tool for implementing models of intelligence. In conclusion, GETMAS is made for building large-scale intelligent learning environments.
8 Acknowledgments

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9 References

Concept-Map Based Navigation in Educational Hypermedia: a Case Study

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Abstract: Hypermedia technology is widely used in higher education and in electronic publishing in general. In order to involve learners in the meaningful cognitive processing of the delivered information, we need cognitive tools such as knowledge-based navigational aids. This paper uses a case study in the domain of psychology of learning and describes what we have learnt from creating and experimenting a navigational aid, based on a conceptual map. We present a semantic network authoring tool, and give a report of our experiments. Findings and benefits are then discussed.

1 Introduction:

Today, the use of hypermedia technology is widespread in higher education. The non-linear delivery mechanism that this approach embodies is also widely used on global networks (World Wide Web) where stored information represents a potentially important resource for education. It has been argued that hypermedia systems can be used as cognitive tools, allowing students to explore and make sense of a knowledge corpus, constructing meaning in a self motivated and self directed fashion and developing metacognitive skills [Jonassen 92][Leclercq 91]. However, hypermedia systems suffer from a lack of structure and of expert guidance in the instructional sequence. Concept-map based tools have been proposed to facilitate both use and development of hypermedia in an educational context [Elliot et al. 95]:

i) tools to facilitate hypermedia use: While skilled users may benefit from complete control over the presentation of the material, it is generally argued that - in an educational context - guidance and structured activities should be provided for the learners who obviously are not domain experts [Laurillard 93][Linard, Zeiliger 95]. According to Reader and Hammond [Reader, Hammond, 94], students should be encouraged to use cognitive tools to structure their thoughts. Some techniques have been explored with the aim of adding instructional guidance in hypermedia: combining intelligent tutoring (ITS) and hypermedia [Bruillard, Weidenfeld 90][Zeiliger 93], making hypermedia adaptive [Brusilovsky et al. 93]; they rely on external representations of domain knowledge (often in semantic networks) - which are unfortunately expert’s representations - and student models. Most of these techniques conceive guidance in terms of restriction of navigation. On the contrary, some navigational aids bring « direction » in hypermedia navigation in the form of navigation enhancements: in this approach the inherent associative structure of hypermedia is not restricted and more meaningful navigation paths are provided to help students make sense of the knowledge corpus. Concept-map based navigation can encourage and help students to construct their own representation of the domain.

ii) Tools to facilitate hypermedia development: There is considerable benefit in finding ways of making hypermedia development easier [Barker 93] and of increasing the use of material developed elsewhere [Laurillard 93]. Hypermedia systems (HMS) have an internal structure which is imposed by the presentation of the content in terms of nodes and links, and by the provision of a set of navigational paths determined by the navigation features. Concept-mapping tools can be used at design time to help authors construct more structured HMS (imposing - for example - a model of cognition of the domain). Ease of use of concept mapping tools can encourage designers engage in knowledge elicitation and representation processes, leading to more rational applications. Although concept mapping approach raises a number of fundamental issues, according to Elliot and al. [Elliot et al. 1995] « explicitly represent the domain, however transitory, can only be seen as beneficial ». Concept-mapping tools can also be used at run-time to give learners the possibility to travel along conceptual
navigation paths. In addition concept-map based navigation allows recorded paths to be used for formative evaluation: teachers can check material visited against test results [Misanchuk, Schweir 92].

According to Elliot and al. [Elliot et al. 1995] « if an authoring environment were to allow developers to « draw » their subject domain on a screen as a semantic net and then add the hypermedia features it would considerably facilitate development ». In this paper, we present a new graphic tool « PHASME » which has been designed to fulfill part of these requirements. However, rather than building hypermedia presentation features according to the semantic net, we started from an already built hypermedia application and we used PHASME to enhance it with new navigational aids: this approach was preferred for the perspectives it could offer on transforming the materials available on existing networks into educational resources.

2 The learning Application: PROLEARN

In our current project, a new navigation facility, based on a concept map of the domain, has been added to an already existing hypermedia software named PROLEARN (Behaviorist and Cognitivist views on Programmed Learning). The original hypermedia concerns the domain of psychology of learning in the format of an Asymetrix TOOLBOOK courseware composed of 157 pages. Presentation is done mainly through text and animated graphics. It is used since 1994 by all students enrolled in Prof. Leclercq’s second year course on « Training methods and Learning » in the Faculty of Psychology and Education (University of Liege, Belgium). Learning is structured into two phases [Linard, Zeiliger 95]: first, during an initiation phase, students review the learning material in a mostly linear way (from first page to last page). Navigation is controlled by using the « next » and « previous » buttons. A few hypermedia side-navigations are allowed along the main way. Second, during a so called testing and reflection phase students are free to access any page in the software. Navigation is done mostly through hot words. Students spend usually 2 hours on the computer, in one session.

In our current project, a new navigation box (NB) - based on a concept map - has been designed (see figure 1). It is provided only during the testing and reflexion phase. It is displayed on the screen at the end of the initiation phase, as a non modal dialog box, so that the basic navigation controls (hotwords and buttons) inherent to PROLEARN are still available; therefore the students can navigate alternatively using the standard buttons or the new features - or both. The concept map describes the domain content in the form of a semantic network: six main conceptual areas have been identified (ex: cognitivism, constructivism, programmed learning, conceptual structure, etc.). Those main concepts are interconnected through intermediary concepts (ex: subsumption, representation, objectives, prerequisites, etc.). The main authors who have coined the concepts are also represented in the network (ex: Ausubel, Bloom, Piaget, Albertini, etc.). Each hypermedia screen (i.e. the basic presentation unit) is also represented. The instances of these 4 classes of object (main-concept, intermediary-concept, actor, screen unit) are connected through non-typed relations (is-related relation). The process of authoring this concept map is explained in section 3 hereafter.

Students do not see the concept map which drives the navigation box. However they can use enhanced navigation features : as soon as a screen unit is presented, the system explores the concept map and displays - in the vertical list box of the navigation box - a list of all concepts, actors and screen-units (named PAGE in TOOLBOOK applications) related to the content presented in the current screen-unit. Then, when the student clicks on a concept in the list, all connected concepts and screen units related to this concept are listed. Whenever a screen-unit reference is present in the list, the student can navigate to it; or he/she can also follow the « conceptual path » linking a chosen concept to the other concepts. In that case the screen remains unchanged. The conceptual paths lead always to a new screen whose content is - in some conceptual way - related to the previous screen. To summarize, the student navigates from the current screen to the next one along any of the relations composing the conceptual network (virtual navigation paths).

The navigation box (NB) offers also the following features:
1) historical navigation (backward along the traveled concept paths).
2) navigation to any screen whose content is related to a given actor (for instance through citations).
3) every student can attach a personal electronic « post-it » to any screen or any intermediary concept; personal « post-it » keep annotations (a free text), appear along the navigation paths and can be accessed directly through the « post-it » list. Post-it navigation provides direct access to already traveled conceptual paths.
4) a simplified concept-map is displayed as well as a simplified representation of the currently explored conceptual areas so that the student can control his/her navigation routes across the 6 main conceptual areas.
3 The authoring tool: PHASME

Those new navigation facilities have been developed with PHASME. This software tool has been designed at IRPEACS with the aim to extend TOOLBOOK with knowledge representation and decision making features. PHASME offers visual interaction: the conceptual network is authored visually, directly on the screen. We now review the concept-map authoring process in order to illustrate the PHASME features.

3.1 Defining a concept-map type: using PHASME’s « metaobject » window, the designer defines the classes of objects and relations composing the semantic net, as well as their properties. This is done in the form of an Entity-Relationship model, through visual interaction. For PROLEARN domain representation, we defined 4 object classes (main-concept, intermediary-concept, actor, screen-unit) and 1 relation class (is-related) which can connect any object.

3.2 Creating a starting concept-map: in a second PHASME window, a starting concept map is created visually by the designer: main-concepts, actors and intermediary concepts are instanciated and named. Yet, no relation nor any « screen » object is yet instantiated. Every concept has a keyword-list property, which is filled in by the designer: those keywords will be used by PHASME scanning functions to identify that a given screen-unit is relevant to a given concept.

3.3 Scanning the hypermedia screen-units and texts: PHASME has been designed to cooperate with TOOLBOOK (through Windows DDE protocol): First, the PHASME « Page import » function scans all screen-units present inside the already existing hypermedia courseware (a .TBK file); the result is the instanciation of the « screen-unit objects » inside the starting concept-map. The designer can then manually specify that some screens must be hidden in the network. Then, the PHASME « Page Match » command scans all texts included in the retained screens (pages) searching for the concept keywords and actors’ names. The result is a network connecting the screen-unit objects to the concept-objects and the actors-objects.

3.4 Editing the resulting net: this computed network is manually corrected by the designer; For instance, in PROLEARN, the computed network had to be simplified: some relations were deleted and a few additional were created. Again, this task is achieved through visual interaction. PHASME provides a set of network intersection functions to help structuring and checking the whole network. In our application, the 6 sub-networks centered on the 6 main-concepts were intersected in order to check their common inter-connections. At this stage, the current semantic network reflects the content of the courseware - but not necessarily the structure of the domain: some discrepancies may be found. As a result of this analysis, it has been decided - in the context of the PROLEARN application - to extend the content by creating a few additional screens; Those screens were
intended to facilitate the understanding of the main-concepts inter-linkage. This is an illustration of the benefit of knowledge elicitation and representation process for designers.

3.5 Designing the navigation box. This is done with TOOLBOOK (we used the MTB30 version). The navigation box is a non-modal dialog box permanently displayed on the screen. It is composed of a few controls (see Fig 1) requiring some script programming. The navigation dialog box communicates with the PROLEARN courseware on one side, through standard OpenScript messages, and with PHASME on the other side, through the WINDOWS user-message mechanism. It should be noted that PHASME is required both at design and run time.

3.6 Programming the navigation buttons (visual agent system). The navigation box buttons send messages to PHASME. Those messages are processed in PHASME’s agent-window which provides a simple visual programming environment to the designer. The so-programmed PHASME agents use knowledge from the semantic net to make decisions whose results are forwarded to the navigation box. PHASME agents are programmable through PHASME script language; this script language allows for PHASME’s networks editing and processing. For example, in PROLEARN, when a student selects a concept « C » in the concept list box, a « navigate » message is send to PHASME. There, we have programmed an agent who responds to this message: it scans the semantic network for connections linking the « C » concept and returns a list of connected concepts and screen-units which are then displayed in the navigation box in place of the current list. The student can then navigate directly to the screens included in the list; or she can also follow the conceptual path by selecting one of the new concepts. To summarize, the designer task at this stage is to create PHASME agents responding to navigation events.

4 Experimentation report

The PROLEARN application enhanced with the concept-map based navigation box has been experimented at the University of Liege, in the Service of Educational Technology (STE). Our main hypothesis was that our navigation facilities would help students construct their own mental map of the domain. More precisely we expected that they could more easily mentally inter-link the 6 main concepts, a learning process which is - from
the expert’s point of view - the key of understanding the given domain (here : Programmed Learning). Thus, students should have better results when post-tested by MCQ examination.

To be more precise, we had expected :
- that the time spent for the task (i.e. answer the MCQ) would increase, due to the navigation cognitive overload for students with little computer experience.
- that our navigation facilities: (i) might offer a lot of possible associations through the concept-map paths - associations who were not necessarily evident for the students - resulting in a better result to post-tests and (ii) might offer an easier access to the different screens, with the result that students would visit more screens.
- that the examination results would be correlated to the student’s recorded conceptual navigation paths (we checked that by overlaying the student’s navigation paths with the expert’s suggested navigation paths).

The experiment was as much « situated » as possible : 84 student volunteers enrolled in the experimentation plan; the PROLEARN domain was part of their standard curriculum; at experiment time, the domain has not yet been taught; the experiment took place in the student’s usual computer room; a real examination was included in the experiment in the form of a multiple choice questionnaire (MCQ testing is usual in that university) ; Students were motivated : in case of success they were partly exempted of the course.

The experiment lasted about 3 hours (there was no time limit), in one hands-on-computer session. The system recorded all navigation actions (average of 500 for each student). Planned activity was as follows : a) system presentation and training (15’), b) initiation phase (almost linear, 75’), c) reflection phase and MCQ examination (free navigation, unlimited time). Students were divided into two groups who differentiated at reflection phase : a group received PROLEARN enhanced with the concept-map based navigation box, the other group used PROLEARN built-in hypertext facilities only (hot words). MCQ was provided on paper (to avoid screen management tasks) but computer was still available : much navigation was expected at that time. The MCQ questionnaire was built out of a question bank (domain : Cognitivism and Programmed Learning). MCQ was validated through a series of methods not detailed here [Leclercq 93]. The student’s answers to MCQ have been computer recorded after the experimentation in order to facilitate the computing of correlation.

Results : the two groups obtained the same global examination results. Total task time was the same for both groups. Students using the navigation box (NB-Students) visited more screens but spent less time in each. No correlation was found when comparing - on the basis of a given MCQ answer - the student’s navigation paths to the expert’s suggested optimal path.

Then the question was : did students use the navigation box correctly ? The evaluation of our navigation device should encompass the navigation box usability (an HCI matter) as well as the validity of cognitive principles underlying the approach. Traces analysis showed that - in the group having the navigation box - only 23% of the students used its conceptual navigation features; most students used only side-features (i.e. not following conceptual paths); however, further analysis showed that both sub-groups (among NB-students) got the same average examination results. Students with high previous computer experience made extensive use of the conceptual navigation features and succeeded well ... but they succeeded as well in other areas within the same course : they appear to be merely « good » students. Referring to Denis and Leclercq [Denis ,Leclercq 85] it can also be said that students demonstrated mathetic ambivalence : a tendency to switch frequently from a discovery and exploratory learning strategy to a more receptive and guided mode, and vice versa).

5 Conclusion

Although they have been used to enhance an application that already existed, concept mapping tools have certainly engaged designers in enlightening activity. Usability of the proposed visual tools seems to be rather good. It is likely that this approach can be applied to hypermedia materials not initially intended for educational purposes. It is still not clear whether the application has really been enhanced by using concept-map based navigation features. Our research tends to show that students did not benefit from the navigation enhancements, however this does not mean that the underlying approach is worthless. Human-computer interaction issues such as interface design, as well as the student’s abilities play an important role : student cognitive overload comes from computer interaction obstacles as well as from domain intricacy. If some knowledge-based guidance mechanisms could potentially reduce the student’s cognitive load, they must not generate interaction overload as a consequence. To sum up, we would say that we were confronted with the dilemma mentioned by Waterworth [Waterworth 94] commenting Norman’s book : « How can artifacts created to serve the function of reducing mental effort be designed to encourage that very effort ? ».
References


Acknowledgements

We are grateful to Prof D. Leclercq for reviewing this paper and for his friendly welcome. We would like to thank the students who volunteered in the experimentation, Jean Luc Gilles and Michel Jacques of CAFÉIM for their support. The work reported in this paper was supported by the « Ministere des Affaires Etrangeres » in France, and by the « Commissariat général aux Relations internationales de la Communauté française de Belgique - Sous commission des échanges scientifiques France-Communauté française de Belgique » in Belgium, Actions Integrees Franco-Belge, programme Tournesol N° 94061. TOOLBOOK and MTB30 are registered trade marks of Asymetrix Corporation.
Cooperation in a Hypertext Environment

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Abstract: Hypertext may have some advantages over linear approach in presenting information and enhancing active learning, but literature indicates that links and connections in hypertext can cause cognitive overload and confusion in navigation. This study investigated whether cooperation between students alleviated the problem. Two treatment groups were compared. In one group, students were instructed to work cooperatively on the hypertext, while in the other group students studied the program individually. The results suggested that cooperative learning facilitates students navigation. It also tends to improve their achievement, although the result was not significant for achievement.

Introduction

Cognitive theorists believe that active learning occurs only when learners use their prior knowledge to interpret new information [Jonassen 1988]. They assert traditional computer-based tutorials and drills, which emphasize associations between stimuli and responses, involve shallow information processing, and are a reductionist approach to learning [Jonassen 1988]. Information in computer-based hypertext is composed of networks of ideas and relationships between the ideas [Tsai 1988]. Hypertext is believed to be able to convey knowledge more easily because the ideas and the relationships are analogous to semantic networks. Semantic networks perhaps represent the way information is stored and retrieved in the human mind [Denenberg 1988].

Although hypertext learning environments provide a greater degree of flexibility for accessing information [Tsai 1988], findings indicate that this can cause navigational difficulties and cognitive overload for learners. The high level of learner control may result in distraction or missing relevant information [Jonassen 1988]. Students with low ability and no prior knowledge are unsuccessful in learning from hypertext [Tsai 1988; MacGregor & Winover 1993].

Studies have been conducted on how interface design and learning strategies may mitigate the problem. Areas that remain to be examined are whether interactions between students affect navigation and achievement. The purpose of the current study was to assess whether cooperative settings facilitate students' navigation and enhance achievement in learning from hypertext.

Review of the Literature

Hypertext Learning Environments

A computer-based hypertext is a large database with links connecting related ideas called nodes. The nodes represent ideas, and the links are relationships between the ideas. Semantic networks in hypertext are intended to emulate the associative way that knowledge is stored and retrieved in the human mind [Denenberg 1988], although hierarchical structures are also found in hypertext programs [Jacques et al. 1993]. One of the purposes of presenting information through nodes and links is to indicate that “any topic is not absolute but relative to its relationships with other topics” [Denenberg 1988]. Cognitive flexibility theory suggests that hypertext can demonstrate conceptual inter-relationships and multiple perspectives of a complex topic. [Spiro & Jehng 1990]. A well designed hypertext system assists learners in constructing their own webs of information, and allows them to add, delete, or change nodes and relations [Denenberg 1988].

Hypertext may be able to convey the relationships among ideas and provide learners opportunities to direct their study, but there are trade-offs. Unlike conventional computer-based instruction, hypertext allows a great deal of learner control. Studies suggest that not all learners are able to make good decisions on control options [Gay 1985; Jonassen 1988; Steinberg 1989]. Literature indicates that there are little differences between learner control and system control for simple tasks. But for higher level learning, learners under computer
control conditions tend to perform better than those under learner control [Steinberg 1989]. The primary aspect of user control in hypertext is navigation, and it often is a problem for students. Large amounts of cross-referenced information make navigation and learning cognitively demanding.

The problem was addressed by research findings. Skills such as planning, organization, comprehension monitoring and prior knowledge are important for successful navigation in hypertext [MacGregor & Winover 1993]. The use of elaboration and comprehension monitoring can lead to better encoding processes and higher performance in hypertext learning [Davidson et al. 1995]. The study by Tsai suggested that learners' ability and prior knowledge of the content area were necessary in learning from unstructured environments [Tsai 1988]. Graphic displays of the structure can assist users in finding pertinent information [Trumbull et al. 1991]. Table of contents and index tools can provide useful guidance for navigation [Jacque et al. 1993]. Advance organizers can increase meaningful interactions between the learner and the program [Jonassen 1988]. Metacognitive cues for using hypertext systems may improve navigation in hypertext learning [in et al. 1993].

In summary, hypertext appears to be an improvement over conventional CBI in presenting complex information and promoting active learning. However, these features bring about additional cognitive demands. Navigational guidance and cognitive assistance are crucial to ensure effective navigation and learning.

Cooperative Learning and Hypertext

Cooperative learning is generally found to be more effective in improving students' achievement than individualistic learning or competitive learning [Slavin 1983; Johnson & Johnson 1990]. As to computer-based instruction, while some research indicated that the mean achievement from group CBI was not significantly greater than individual instruction [McNeil & Nelson 1991], other studies suggested that students working in cooperative CBI outperformed those working individually [Dalton et al. 1987; Yueh & Alessi 1988], and working in pairs improved the use of learning strategies and attitudes toward CBI [Rysavy & Sales 1991].

Why does cooperation tend to enhance learning? Brown and Palincsar [Brown & Palincsar 1989] suggest that first, cooperation provides shared responsibility and expertise for thinking. It reduces the thinking load that each individual would otherwise have to take by him or herself. Secondly, cooperation provides opportunities for cognitive modeling and scaffolding. Cognitive and metacognitive strategies, such as defining problems, organizing information, referring to context or past knowledge, and evaluating progress, are executed overtly. The observation and discussion in the group enables each member to witness and share with others the use of thinking strategies. Thirdly, clarification, justification, and elaboration (the reflective and monitoring activities) among group members enhances knowledge retention and transfer. Smith and Confrey [Smith & Confrey 1991] maintain that peer collaboration offers opportunities for individuals to bring forth multiple interpretations and understandings of the situation in the lesson. In the course of solving the problem, each of them constructs his or her own meaning within a shared world.

Cooperation facilitates learning because it creates an environment in which students interact with each other to generate learning strategies and integrate new information into their existing knowledge. Such kind of environment is helpful to solve the problems that students face in learning from hypertext: cognitive demands and navigational confusion.

Methods

Purposes of the Study

Planning, elaboration and comprehension monitoring are identified by studies as important factors for effective hypertext learning, and cooperative learning is found to facilitate the use of these strategies. Therefore, the researcher of this study hypothesized that cooperation would help students make better decisions in navigating and exploring the hypertext. Students working in dyads would navigate in the hypertext more effectively than those working individually and would show better performance. Specifically, this study was designed to explore these questions: how do the pathways taken by dyads differ from those taken by individuals while studying information related to the instructional objectives? Do students working in dyads show better performance than the individuals in studying the information in the hypertext?

Subjects
Forty undergraduate students (10 dyads and 20 individuals) from a major Midwestern university volunteered to participate in the study. They did not have experience working with hypertext and had not taken any college-level courses related to the content of the hypertext.

Program Content and Interface

The hypertext database is on the fifth to the third centuries B.C. Chinese history. This is the period when China experienced enormous changes. The interrelated aspects, including wars between the feudal states, contact with nomads, economic development and advent of schools of philosophy, make the material a good candidate of hypertext-based learning. The Taoist philosophy was selected as the primary instructional objective to keep prior knowledge the same for all subjects, as it is not known to many American students. Students' prior knowledge should therefore not account for any differences between the dyads and the individuals in the study.

The hypertext program was developed by the author with HyperCard 2.2. The database consists of 75 cards. Information is presented mainly through text, although 14 graphics are used for motivation. Networks and hierarchies constitute the structure. The introduction card contains the major topics of the content, and can lead to deeper levels of the topics. Students move around in the hypertext by clicking on hyper-links or one of the functions, which are Exit, Index, Timeline, Search, Previous, and Help. The functions are always available on the computer screen. All topics in the hypertext are listed and organized by four categories on the Index page, and each topic is a hyper-link. Events and people are organized in chronological order on the Timeline page. The Previous function lets students backtrack. No forward function is included in order to avoid students following a linear sequence like reading a book. Search enables the student to locate particular words in the hypertext.

Structuring Cooperative Learning and Conducting the Study

Twenty students were randomly assigned to ten dyads. Group goal and individual accountability were stressed in structuring cooperative learning in this study. The goal for the two people in the dyad was to get the highest or second highest combined scores among the dyads in the post-test, which they took independently. (The reward was a music CD for both members.) Dyads were told that they were more likely to reach that goal if they helped each other study and review the information related to the instructional objectives, which were indicated on the organizer questions on the worksheet. Dyads were also asked to follow the learning strategies on the worksheet, which included making decisions together, tutoring each other and sharing responsibilities.

The goal for individuals was to get the highest or second highest score in the post-test in order to get a music CD. The worksheet for individuals also included the learning strategies, which focused on planning the study, monitoring the learning process and note taking.

Based on the times students signed up for the study, the researcher randomly assigned those who would participate at the same time to individualistic or dyadic groups. All sessions were conducted in a computer classroom. The members of a dyad shared one computer, and each individual used the system by him or herself.

An oral presentation on the objective and procedures of the study, the reward system, and interface features of the hypertext was made before students ran the program. Then worksheets were given out. The students were reminded to pay attention to the organizer questions and the learning strategies. Forty-five minutes was allowed for studying the lesson. Students’ notes were collected before they took the paper-and-pencil test. Navigational data were recorded by the computer for analysis.

Measures

The study was to investigate whether cooperative learning helped students navigate more effectively and if it improved students’ performance. The pathway taken was examined for the effectiveness of navigation. The computer recorded the sequence of screens that each dyad and individual visited. Two individuals exited the program inappropriately. Their data were not used for the analysis.

The pathway consists of individual decisions. After finishing studying the information on a screen, the student or dyad had to make a decision as to which hyper-link or special function to select next. Procedures were established for scoring the decisions. A 7-point scale was used with 7 indicating the best decision and 1 the poorest decision. An example of a 7-point decision is to select a school of philosophy on the index page, since the instructional objectives asked the student to identify the philosophy which addressed the origin of human beings. Selecting "Invention of Iron" on the index page would be an example of a poor decision, and “1” would
be assigned to that decision. “3” would be assigned for clicking on the Index function after the student has wandered among pages irrelevant to the instructional objective.

Following the procedures, the researcher of the study scored the pathways and re-did the scoring two months later. Scoring was done blind to student identity and treatment group. The correlation of the first and second scoring was .982.

The analysis of achievement was based upon students' scores in the post-test. The test was composed of 4 true-false, 2 multiple-choice and 2 short-answer questions. Face validity and instructional validity of the questions were inspected by the author and one content expert. The scoring of the short answer questions was based upon the key that the researcher and the content expert agreed upon. Students' responses to the short-answer questions were independently scored by the researcher and the content expert. Both graders' scoring was done blind to student identity and condition, the correlation between the scorings was .964.

Results
Pathway

To determine whether one treatment group navigate more effectively than the other in the hypertext, the pathways taken by 18 individuals and those by 10 dyads were compared. The effectiveness of the pathway was measured by averaging the points of the decisions. The mean for individuals was 3.64 (SD = 1.27), and 4.33 (SD = 0.63) for the dyads. The results of the analysis are reported in Table 1 [Tab. 1].

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>N</th>
<th>MEAN</th>
<th>STDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyads</td>
<td>10</td>
<td>4.33</td>
<td>0.63</td>
</tr>
<tr>
<td>Individuals</td>
<td>18</td>
<td>3.64</td>
<td>1.27</td>
</tr>
</tbody>
</table>

Table 1: pathway scores of cooperative and individualistic groups

A t-test was performed to compare the navigation of the two groups. The result demonstrated a significant difference (t=1.91, p=0.037), indicating the pathway taken by dyads were more effective than those taken by individuals. Other descriptive data supported the analysis above. Seven out of the ten dyads (70%) began their study by browsing through the top level of information of each philosophy, while for the individuals, the ratio was 44%. Two out of ten dyads (20%) did not seem to focus much on the instructional objective, 39% individuals focused their attention on non-philosophy information.

Achievement

Scores of the items related to the instructional objectives measured students' achievement. The total scores was 10. The hypothesis that dyads would have better performance than individuals was assessed by a t-test. The results of the analysis are presented in Table 2 [Tab. 2].

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>N</th>
<th>MEAN</th>
<th>STDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyads</td>
<td>20</td>
<td>4.75</td>
<td>2.05</td>
</tr>
<tr>
<td>Individuals</td>
<td>20</td>
<td>4.25</td>
<td>2.97</td>
</tr>
</tbody>
</table>

Table 2: post-test scores of cooperative and individualistic groups

The results did not indicate a significant difference between the two groups (t=0.73, p=0.24). Therefore, there is no evidence that the dyadic settings improve learning from the hypertext program.

Discussion
This study examined two settings for using computer-based hypertext. In one treatment, students worked individually; in the second treatment, they worked in dyads.

Having students work in dyads facilitated pathways of navigation in the hypertext, in contrast to individuals. This result is consistent with findings that interactions between students may facilitate the generation and the use of learning strategies, and the use of strategies such as elaborations and comprehension monitoring leads to deeper processing of information and better decisions (such as what pathway to follow at any point) towards achieving the instructional goal. Descriptive data reveals that dyads’ exploration appeared to be more focused and plan-driven than that of the individuals.

Having students work in cooperative settings through the hypertext did not lead to higher achievement in hypertext learning. Research findings that cooperative learning enhances learning on CBI were not supported by this study. This may result from the implementation of cooperative learning methods. Interviews with several dyad members revealed that not all dyads followed the suggested cooperative strategies because they were not accustomed to the strategies. Some students did not feel comfortable working with their partners because the dyad members did not have enough time to get to know each other. To fully take advantage of cooperative learning, future studies should pay attention to training the students on the use of cooperative strategies.

Findings of this study indicate that cooperative learning is potentially capable of improving students' navigation, and perhaps their achievement in learning from hypertext. However, careful implementation of cooperative learning, that is, to include training sessions on how to use the strategies and allow some time for group members to get used to working with each other, is necessary to ensure successful learning experience.

**Literature References**


Acknowledgments

I would like to extend my gratitude to Dr. Stephen Alessi, the University of Iowa, who provided great advice on the research and the writing of this paper. Special thanks are due to Dr. James Quinn and Dr. Margaret Lehman for their comments.
ROUNDTABLE
During the past decade there has been a tremendous growth in computer-mediated communication (CMC) on university campuses. It is now common for faculty members to receive electronic mail (E-mail) on two or more systems from staff and students as well as local and distant professional colleagues. The rate of message delivery appears to be accelerating. At some point, "more" information will cease to be better and faculty may be forced to implement protective mechanisms to avoid becoming overwhelmed. This paper provides a first approximation of the rate at which faculty E-mail is approaching information overload at one large, central U.S. state university, and proposes a simple metric for judging the utility of an E-mail system, from the perspective of an individual.

The first author obtained his initial CMC account in 1972 and has had access to between 1 and 5 systems each year since that time. Information flow for the first 15 years can best be described as a trickle, followed by 5 years of slow growth, followed by 3 years of rapid expansion. The rate of increase for incoming messages calculated from six months of data ending September 1995 was approximately 68% per year. A timed test conducted on a sample of these messages led to the estimation that 1.5 hours per working day would need to be devoted to processing (scanning, responding or deleting and filing) the September, 1995 information flow, in order to stay up-to-date. If this historical trend is projected forward slightly more than one year, then the incoming message load can be expected to rise from the September 1995 level of 340 per month to almost 700 per month by October, 1996. The implication of this data is that many university faculty will soon be plagued by what [Hiltz & Turoff, 1981] defined as information overload.

Several studies have pointed out benefits of E-mail systems to organizations such as universities [Garton & Wellman, 1995]. In this section, we propose a simple measure for assessing the utility of an E-mail system to an individual: (messages sent - messages received)/(messages sent + messages received). The resulting ratio can range from -1 to +1. The index has been named the Virtual Influential Person (VIP) Ratio, with the ideal ratio for most faculty proposed to be 0.0. The system from the point of view of an individual is unbalanced whenever the ratio deviates far from this point. As the ratio becomes closer to the lower limit of -1, the system is more of a nuisance to the individual. Conversely, as the ratio rises above zero and approaches the upper limit of 1.0, the system is becoming more of a tool used by the individual to influence other people. For example, one E-mail system commonly accessed by the first author for on-campus communications had a VIP index of -.85 during 1994-95. Another system commonly used for scholarly communications via the Internet had a VIP index of -.29 during 1994 and +.10 for 1995. The latter system can be classified as better balanced than the first, for this user.

Organizations may have individuals (Deans, etc.) identified as holding rightful positions of influencing others. Organizations may also contain individuals who do not hold formal positions warranting high VIP indices but who nevertheless possess high ratios. We might say that the latter individuals are misusing or taking advantage of the system. More important for the current discussion is the group of individuals who may be disadvantaged by the system. It is hypothesized that many faculty fall into this category. They typically have neither the time nor the inclination to "fight back," (send barrages of messages of their own) because much of the information overload may be coming from people hired to support them. [Motiwalla & Aiken, 1993] have pointed out that E-mail information overload commonly occurs “...because e-mail technology facilitates quick and massive distribution of a message to other people with little extra effort (p. 266).” It may be those sending messages to hundreds, perhaps with good intentions, are unaware that they are making it very difficult for others to do their jobs.
User education and self-regulation may be the best hope for curbing information overload in the long run. For now, when the excitement about E-mail is still on the rise at college campuses, a measure such as the VIP Index may help individuals judge the benefits and disadvantages of any given system in terms of their own time priorities and constraints. As long as current attitudes surrounding E-mail on college campuses remain intact, it does indeed appear to be better to give than to receive.

References


Making the Most of Learning Opportunities: The Role of Reflection for Action, on Action, and In Action

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Introduction

In this session, we will discuss work-in-progress on *Making the most of learning opportunities: the role of reflection for action, on action, and in action* between collaborators at University of Southern Queensland in AUSTRALIA and Heriot-Watt University in Edinburgh UNITED KINGDOM.

A learning opportunity is any "significant incident" or "key event" that presents a learner with an opportunity to relate authentic experiences in practice with learned concepts. Learners can learn to do this by keeping learning logs on a regular basis. A learning log is a reflective record of learning events that a student encounters in a course. Such a log records how the student approaches the tasks and activities of the course and records their expectations, their successes, their problems and issues that need to be resolved. A learning log is a form of self-assessment. The critical attribute of the learning log is that it helps the learner concentrate on the process of learning. As learning can be seen as the result of engaging in tasks, it helps the learner identify the antecedents to learning. The learning log is not a diary of events, nor is it a record of work undertaken, rather it is a personal record of the occasions when learning occurs or might have occurred. Basing these observations on Schon's work (Schon, 1991), it is predicted that a learner's ability to reflect IN action and recognise learning opportunities, is dependent on training and practice in recording reflection ON action. - ie the events that lead to learning.

Learning/Teaching Problem

Students have generally been found to be somewhat restricted in applying their education and theoretical knowledge to practice. They often miss opportunities to relate experience to prior learning. Students and student practitioners, such as nurses, teachers, or engineers are confronted on a daily basis with incidents which present learning opportunities. They need to be helped to recognise the significant events that lead to learning from everyday events. Learning opportunities have to stand out from such events. Instructors have a related problem. This has to do with their ability to develop in learners skills needed to recognise a learning opportunity which is a useful higher-order cognitive (or meta-cognitive) skill. Good teachers are constantly searching for powerful strategies to develop this skill in learners in order to optimise student's learning capability so that they can learn from events in their workplace on a day to day basis. Transfer of learning or training horizontally (from theoretical content to authentic experience) and vertically (from one authentic practice event to another) have been addressed in these projects.

Questions

The research questions we have been addressing as part of our work are presented below. These will provide the framework for our round table discussion.

- How can learners be helped to recognise learning opportunities?
- How can learners be taught to keep logs of learning opportunities?
- Does keeping learning logs influence success in particular kinds of tasks?
- Does the sharing of learning logs have particular advantages for the group?
- Does the mode of lecturer feedback on learning logs impacts on learning outcomes?
- What is the role of the lecturer in helping learners make the most of learning activities?
Methodology

Several studies have been carried out in the last year to explore these questions. The independent variables in these studies have been the strategies for recording learning opportunities and the dependent variables have been student*s performance on the assessment measures in the unit, qualitative and quantitative responses to questionnaires/interviews, and confidence and ability at identifying a learning opportunity and also at making use of a learning log. Preliminary data from the studies have revealed the following trends:

- improvement in learners* ability to maintain learning logs; and
- improvement in learners* ability to recognise learning opportunities.

References

The most important activity children can do to enhance their reading ability is to spend time reading. However, students must be motivated to read. One way to accomplish this is through the use of technology.

Basic Assumptions About Reading

- The most important activity children can do to enhance their reading ability is to spend time reading.
- Students must be motivated to read.
- Well-trained and dedicated teachers are important.
- Word-recognition skills and vocabulary development are crucial to the reading process.
- Reading ability is related to language ability.
- Writing skills are important in the development of reading skills.

Tips For Using Technology To Motivate Readers

- Ask children to share their experiences. This will contribute to meaningful learning.
- Keep in mind the prerequisite skills that are required to use the technology. Students will approach technology from different levels of experience.
- Be sure to give the student proper instructions and training. Students may feel frustration and anxiety if they experience problems using the technology.
- If possible, work with students on an individual basis until they feel comfortable with the technology.
- Use small groups, co-op learning, and peer tutoring. This will provide for efficient use of technology and enhance the learning process.
- Invite children to read, to predict events, and to retell stories. This will aid in comprehension, sequencing, vocabulary development and promote critical thinking skills.
- Encourage the children to explore. Their enthusiasm for learning will be increased and they will learn to enjoy to read.
- Effective application of technology to learning involves a series of steps. Use an instructional design model to implement technology!

Other Suggested Reading Activities with Technology

- Have students publish classroom newspapers and books.
• Encourage students to create a fictitious business complete with graphics, advertising, accounting, and sales departments.
• Link with online communications such as bulletin boards, internet, library and university systems, and communication services.
• Consider the following types of software to motivate readers: games, edutainment, desktop publishing, graphics, test preparation, study skills, music, photography, database, and spreadsheet.
• Incorporate reading activities using other technologies such as the fax, scanner, interactive television, video camera, and vcr.
Redesigning Courses for the Computer

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For the past twenty years, the University of Pittsburgh External Studies Program has developed courses for independent study. Rapid developments in technology have recently raised questions as to how the computer can be used to deliver distance education. In this round table discussion, we will present printed materials, originally designed for an architecture course that have been redesigned for use on the World Wide Web. Specifically, we 1) discuss why we are redesigning this course for the computer; and 2) focus on the differences between the computer and print based media when considering Gagne’s (1992) events of instruction.

Examples of some of the changes are as follows:

<table>
<thead>
<tr>
<th>Print Based Course Materials</th>
<th>Computer Based Course Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Students go back and forth between descriptions and pictures.</td>
<td>Pictures and the related text are combined in the same screen.</td>
</tr>
<tr>
<td>2) Used photocopies pictures in the study guide due to cost restrictions - fidelity and clarity in the pictures were low.</td>
<td>Scanned photographs - better resolution and fidelity. Easier manipulation of the images to meet specific objectives.</td>
</tr>
<tr>
<td>3) Long descriptions to made up for the low fidelity of pictures.</td>
<td>Descriptions are brief - pictures tell the story. Content is divided into smaller units, which make the concepts and the overall structure much clearer.</td>
</tr>
<tr>
<td>4) Architectural terms needing clarification are included in a separate section.</td>
<td>Hypertext helps students jump to the appropriate definition, to link to extra examples and to link to other relevant sections.</td>
</tr>
<tr>
<td>5) Allowed only static representations of pictures.</td>
<td>Zooming features get close ups of detail, show cross sections and how cross sections relate to the whole.</td>
</tr>
<tr>
<td>6) Activities had to be separate from the content. Immediate feedback not possible. Not Interactive.</td>
<td>Activities intertwine with the content and immediate feedback. Students give each other feedback using e-mail. Pictures are easily included in assessment activities</td>
</tr>
</tbody>
</table>
7) Students cannot manipulate various architectural elements

8) Cannot discuss two topics or show or concept map and content at the same time clearly.

Eventually, we hope to create a “playroom” in which students can combine various architectural elements to see what effects they have.

Eventually, frames or windows can be used to compare and contrast two ideas or concepts, to show multiple views of a structure and to show a concept map or menu.

<table>
<thead>
<tr>
<th>Table 1: Differences between print based materials and computer based materials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The redesigning process can be laborious. UESP has attempted to identify courses that are amenable to computer based instruction and redesigning them so that they are grounded in the principles of instructional design. We hope that this course will serve as a model for other faculty, who are interested in web based instruction.</td>
</tr>
</tbody>
</table>

References

PANEL
From Straitjackets and Blinders to Infinite Space:
Using the Internet to Transform Writing in the Classroom

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Introduction

In the Preface to The Electronic Word, Richard Lanham comments: "Electronic text creates not only a new writing space but a new educational space as well." [Lanham, 1993] This panel addresses the ways in which, computer-mediated communication transforms and extends the "writing space" beyond the physical limits of the classroom. In ways not possible before, students become aware of multiple audiences and begin to perceive themselves as active learners in an environment where they not only "consume" texts but produce their own texts for wide distribution. Hamlet's sarcastic jibe, "I could be bounded in a nutshell, and count myself a king of infinite space" [Shakespeare, 1974], is more prophetic than Shakespeare could have imagined.

The shift to computer-mediated communication at the University of Missouri-Columbia has had a major impact in several programs. As an IBM-sponsored Center of Excellence since 1989, the MU School of Journalism has conducted a variety of computer-mediated instructional methodologies on its 315-computer network called "J-Net," which links its classrooms, newsrooms and faculty offices. In the Fall of 1994, the English Department, the Writing Lab, the Campus Writing Program and Campus Computing initiated a collaborative "Writing with Computers" project designed to introduce more students to computer-mediated writing. In the first semester, we offered four sections of basic composition, two of technical writing, an undergraduate course in Shakespeare, and a graduate-level history course in research methodology. In the Winter of 1996 more than twenty-five different sections or courses, all all levels, were accommodated within this project. The transformation of the writing classroom, however, depends upon collaborative efforts and close attention to pedagogy.

Providing Support

In August 1994, at the start of the "Writing with Computers" project, Campus Computing already had a solid foundation in instructional technology. We operate fourteen student computing facilities with about 850 work stations, and twenty-six smaller clusters in the residence halls. Each site is networked within the lab and linked to the campus fiber optic backbone, allowing for mainframe and Internet access. In Winter 1995, 24,000 students had userids on MU’s shared systems, and a great many courses were designated as computing intensive. Sixteen technology class rooms are available for instruction. The courses taught in these rooms range from English 20 to Landscape Design to Engineering and the entire Calculus sequence. Given our prior experience with the School of Journalism when J-Net was established, we assumed facilitating this new project would be easy.

We quickly learned, however, that there was much we did not know and we spent the first semester of the project learning that good intentions were not enough when it came to implementation. The first step in the project was renovation of traditional classroom space. The Registrar’s office (which really should be included as part of the
project team) gave up three small traditional classrooms adjacent to an existing computing lab/classroom. We turned this space into two twenty-seat classrooms with a movable partition allowing it to be used as one forty-seat classroom when needed. The room is equipped with PowerMac 6100's placed in a fairly traditional lab setting. The only variation on our other computing sites is the use of recessed monitor tables so that when one enters the room, it is not immediately obvious that it is a computing classroom. Whiteboards at either end, two pull down screens and two Proxima projectors complete the layout.

Given the variety of courses to be offered in the first semester of this project, we realized there would be challenges to our present use of technology in the classroom as well as our expected educational goals. Several factors which affected implementation for the first semester, however, were not apparent at the start of this program. First, we did not anticipate the reaction of the graduate teaching assistants to the change in teaching methodology. Of course, renovation ran behind schedule so that we were scrambling to install tables and set up equipment the night before classes began! As a consequence, we seriously neglected initial training for the teaching assistants, not only in how to operate the room and get their students started but in very fundamental ways, like teaching the teaching assistants how to use the very electronic mail system they were to have their students use.

Second, we did not realize that the technology would make it possible to move toward a paperless classroom. Again, with little time for actual coordination between Campus Computing, the English department, and the teaching assistants using the technology rooms, a decision was made to encourage on-line discussion and submission of "papers." Students in Turbo English (as the sections of English composition taught in these rooms are referred to) do virtually all classroom discussion on-line during and outside of class. They use email to submit their own work and to critique the work of fellow students.

Third, while we anticipated the need for more tutorial services for students and orientation/training services for the teaching assistants and site support staff, we underestimated what the demand would be. The room setup took precedence over training of the teaching staff. It also interfered with the interaction of the computing staff with the teaching staff so that when problems arose, teaching staff did not know how to get help. Instead of doing what seemed logical to the computing staff (i.e., asking the student assistants or calling the Help Desk), we found flame wars starting on class discussion lists. Thus we had to teach some of the teaching staff who to ask and how to ask a question of the computing staff. Student assistants in the computing lab had to be taught how to work with non-computer literate teaching staff, and the particular demands of their students.

Eventually, in addition to increased tutorials and electronic discussion lists, we were able to address other tutorial needs through the On-Line Writery, staffed by the Learning Center. In essence, it functions as a virtual place for students to go for help with their actual writing assignments and as an intermediary service for software questions related to the instructional use of the email package. An important lesson from our experience with this project is that problems related to the technology often can be handled along with pedagogical difficulties.

J-Net

The J-Net, which is linked by fiber optic backbone to the University's mainframe system, provides a fertile laboratory for studies in a variety of computer-mediated environments, involving both teaching and research. The decision to equip each individual workstation with multimedia capacity has proved invaluable for furthering all our goals. J-Net has facilitated research in the cognitive processes in writing and functions in a great variety of ways. It provides for newsroom/classroom linked writing tasks and facilities, including a dedicated MUSH. We have been able to create CD-ROM based simulations to assist in reporting/writing. The design of a keycapture software program for use in self-analysis and office counseling on writing problems has been a great boon to instruction and research, especially in working with ESL students.

A demonstration, with the use of a Powerbook, of both the CD-ROM and keycapture applications provides a sense of how we have been able to enhance teaching and research. Current and recent studies also address a variety of questions that lie at the heart of our use of computers for writing and learning, including such questions as these:

* Can a keycapture program improve the writing process by encouraging self-analysis? A special group for analysis includes ESL students.
The Web-based Paperless Classroom

With the new technologies, one "innovation" inevitably seems to lead to another. Teaching a variety of upper-level English and interdisciplinary courses with increasingly sophisticated electronic communication "tools," the use of a web-based approach to student interaction in and out of the classroom not only made it easier to work with a paperless approach to student work, but to startling changes in teaching.

Perhaps the most problematic course in the English curriculum is the typical survey, usually conducted over two semesters, that attempts to "cover" the tradition of British or American literature from the earliest be ginnings to the present. In traditional courses students are asked to read a dismaying amount of material, from complete texts to "snippets" culled from lesser works. Instructors do most of the talking while students become passive listeners. In a Web-based Paperless Classroom, students and their learning become the central focus. The web site pro vides an environment where students can engage in interactive peer group work and in-depth discussion of particular texts. The technology allows for a greater focus on the critical issues of literary theory and canon formation.

Engaging students in on-line discussion with each other, in on-line peer reviewing, and in electronic submission of their polished work, involves them with the course material and with each other in ways that enhance their learning. Computer-mediated writing and discussion also prepares them for a world in which the electronic transmission of information is now routine. Finally, the web site provides an archive for student work where issues may be revisited and thus creates a clearer sense of the very "purpose" of the humanities to maintain an historical continuum of human learning and discourse.

Conclusions

Adapting the new technologies for educational uses is not simply a matter of having the right hardware and software. The best classroom arrangements will not work without a number of partnerships needed to establish and support these enterprises. The conclusion we have come to in all our work is that the problems we face in adapting the new technologies to new learning are pedagogical not technical. All of us involved in the establishment of writing classrooms at MU believe we have been successful. There have been bumps and bruises along the way, and no doubt these will continue, but we know these projects were worth undertaking and will only get better with continuing collaboration.

References

Educational Applications of Virtual Reality

Overview of Virtual Reality

Virtual reality (VR) is a computer-based technology which provides visual, auditory, and tactual stimulation from a real-time computer generated world--while severely restricting sensory input from the real world. The person interacts with this artificial world as if it were the real world.

Virtual reality emerged from work conducted over the past 40 years in a number of different fields. It represents a milestone in the history of the development of computers, following and extending work in graphics and multimedia. Its roots, however, are entrenched in the entertainment and the defense industries, as well as traditional scientific laboratories in higher education.

A number of individuals contributed to advances in VR, including Morton Heilig, Myron Kreuger, Thomas Furness, and Jaron Lanier--each of whom has come to be known as "The Father of Virtual Reality." A full account of early activities is provided by Rheingold (1991); other valuable information on VR is provided by Pimentel & Teixeira (1995).

Educational Applications

Educational applications of Virtual Reality are essentially at the beginning stages, due largely to the requirement for high speed computing capability and specialized equipment, resulting in higher costs than uses of multimedia in general. At this time, however, significant work is ongoing both in US elementary/secondary schools, as well as the nation's universities and museums.

Much of the work in US secondary/elementary schools is being coordinated by the Virtual Reality and Education Laboratory at East Carolina University. In addition to providing a clearing-house for information about uses of VR in instruction at these educational levels, specific applications in history and mathematics have been tried by teachers working closely with the Lab. VREL's journal, VR in the Schools, seeks to help educators spread the word about VR applications they have tried in the classroom. The Lab's web page contains links to other VR education sites and publications.
At VR levels requiring greater computing power and supporting equipment, pioneer work has been conducted at Carnegie Mellon University and ERG Engineering. At Carnegie Mellon, work was initiated several years ago which resulted in the development of the VR simulation, *The Temple of Horus*—this was followed recently by *Virtual Pompeii*. Both works are carefully re-created visual worlds based on authenticated historical data.

The work at ERG Engineering is concerned with the design and development of interactive virtual worlds based on actual archeological evidence. The vision is to create a globally integrated and interactive system based on a series of linked virtual worlds that can be used for teaching, research, archeological fieldwork, and museum exhibitions. Three major projects are underway, based on archeological evidence from ancient Egypt, Nubia, Greece, and Turkey. These include *The Fortress of Buhen*, Nemrud Dagi, and Temple B700 at Gebel Barkal.

Although in its infancy, the use of virtual reality in education is likely to mature at a fast pace. Due to the rapidly increasing availability of computing power at decreasing costs, use of VR in education may well reach a reasonable use level as early as the year 2000.

References


Schools are investing millions of dollars in technology and are accountable to taxpayers. Thorough technology planning provides the framework for responsible and creative use of limited funds. Extensive pre-planning helps districts sell a plan to the community, creates a format for staff development, identifies why equipment is needed, and explains how technology will enhance student learning.

The practical experience of developing a school district technology plan, approved at the 1.44 million dollar level, has led Dr. Mary Flynn-Maguire and doctoral student, Cheryl Zupan, to acquire numerous resources on the art of technology planning. They have utilized a team and consensus model for technology planning which they utilize in working with other school districts. Jill Cullen has successfully overseen the entire process of technology integration in private schools, from the development of a technology plan, to the installation of wiring and hardware, as well as the critical issue of staff development. The panel will address strategies and skills for developing a plan. The presenters suggest ten steps to ensure that technology is utilized efficiently:

Build a Team Including Board Members, Board of Finance Members, Teachers, Parents, Administrators, and if Appropriate, Students

Building a team that will work well together is essential. Before beginning, a core of administrators, teachers, or board members should discuss the size and scope of the technology planning. Involving people with different areas of expertise and experience will make the committee stronger. Teachers, administrators, parents, board of education, and if possible, board of finance members should be involved in the planning process. The more people that represent the views of their constituents early in the planning stage ensures that the plan becomes more credible as it is presented at varying stages in the community. Moreover, parents, community members, and board members bring a perspective from outside of schools and can be instrumental in leading conversations in the community.

Early in the planning stages, a chairperson or persons should be established, and the group should reach consensus on the format for meetings. Agenda with beginning and ending times should be distributed to all committee members at least three days before the meeting. And, if work outside of the committee should be completed, a “homework” category reminds members of the committee’s expectations.
Assess What Is and Consider What Could Be

When an architect designs a space or a house, the design is site specific. The design is based on the needs of the client. The same should be applied when starting or expanding information technology in the school environment. The aim of any information technology program is to expand the use of all technology across the curriculum as a tool to learning.

In order to begin, one must assess the curriculum as well as the existing technology in the school environment. This assessment is two-fold. On the one hand, you must take an inventory of all equipment and then you must survey your staff and find out what the level of enthusiasm and what their level of experience is with various technologies. Start in the school library media center where all students convene and are able to use the technology for research as well as report writing. All curriculum flows from this site and can feed the classrooms. In this location, a whole class can work simultaneously and staff development can also take place. Whether you start with four computers or forty, the library media center should be where you begin your assessment of what and how technology will influence the school’s curriculum.

Keep Student Needs and Curriculum at the Heart of the Discussion

When developing a comprehensive technology plan, it is very easy to begin with defining uses of hardware. The newest technologies are always appealing and one can easily be lulled into focusing on how our students can benefit from them. This is not to imply that this is all wrong; rather, it is misdirected. Keeping student needs and curriculum at the heart of the discussion is essential to developing a meaningful plan for the integration of technology into teaching and learning. How, then, does one go about this?
A team with a broad base of members will bring to the discussion many points of view and experiences. The chairperson must help the group develop a consensus as to what they want to accomplish. The details are much easier to work out, if the committee is united in their goal. Questions which committee members must focus on include:
• What do our students need to know and be able to do?
• How can technology enhance our curriculum?
• How can technology be a tool for all learners, students, teachers, and administrators?

As these questions are answered, the content of the plan will develop. It is our strong belief and experience that curriculum and student needs must drive the development of the plan. Out of these, hardware can be determined, software identified and evaluated, and staff development begun.

Identify Curriculum Areas Which Will Be Enhanced By Use of Technology

When identifying curriculum areas to be addressed, begin by asking teachers, parents, and students, to talk about units and topics that are already taught and studied. These are the areas where technology can fit in most seamlessly. If a school has little or no current technology to preview software, form smaller groups within the technology committee into four areas: primary, intermediate, middle school, and high school. At this point, a subcommittee can preview current software or even read software catalogues to identify areas of the curriculum where technology connects best. Gone are the days when technology is an add-on to curriculum. Current research indicates that children use technology as a means to an end. Of course, technology can also be an end in itself as students use it to create multimedia reports and presentations as a form of assessment.

Let Needs Drive Budget

Once you find out where you are, you can begin to formulate a plan of where you want to go and where you want to be in one year, two years - each year at a time. The allocation of all of the costs of technology must be included in your budget planning process. Computer staff, staff development, service and repair of equipment, software, CD ROM’s electricity, furniture, presentation devices, telephone bills, as well as, hardware must all be considered when making your plan.
It is important in the assessment, that the school targets the needs of the children and how the technology will support those needs. Grants can be written and fund raising events can contribute to the development of a technology budget.

Identify Processes for Developing Wiring and Hardware Plan

The expertise of committee members will direct the development of the wiring and hardware plans. In many cases, a technical consultant can be hired to translate the curriculum demands into wiring and hardware specifications. The preferred model of technology integration is classroom based. A state of the art computer lab for full class instruction and staff development is recommended to be a part of the library media center. Research conducted in this setting can then be supplemented by the computers installed in each classroom. Similarly, research may be conducted in the networked classrooms which have access to the library holdings, as well as, reaching outside the school and the Internet. The wiring plan should allow for plug in of multiple portable computers which may be brought to the classroom and for possible future expansion of technology.

Identify Impact on Operating and Capital Projects Budgets

Identifying items that impact annual operating and capital expense budgets brings credibility to the plan. This task becomes easier for committees when administrators and board members are active members of the committee. Nevertheless, operating budget items would include personnel, staff training, on-line services, and, in many cases, software. Capital expense budget items normally include equipment, computer furniture, wiring, and basic operating software.

Address Politically Sensitive Questions and Appropriate Answers

Information technology and its integration into the school environment can be a political hot potato. It is important to inform and educate the people making the financial budget decisions. The Board of Education and the community must recognize the inevitable changes in the content of the school curriculum as it adjusts to the technological and educational changes in society. Not everyone agrees that technology is an important component in the education environment. You will face this as you begin the planning and proposal process. However, children today are students of the Information Age. The sheer quantity of learning taking place in our world today is already many times greater than when we were all in elementary school. The most important skill in 1996 has already become the ability to learn new skills, take in new concepts, assess new situations and deal with the unexpected. The technological revolution that has been responsible for the acute need for better learning also offers the means to take effective action.

Plan for Staff Development

The need for staff development cannot be underestimated and must be budgeted for in a sound manner. To meet the diverse needs of all educators, a three tiered staff development plan which will be ongoing and systematic is recommended.

- The committee must first raise the awareness level of all educators and staff, board members, and community members as to what technology integration means for them. Presentations, newsletters, and ongoing dialogue regarding technology which answer frequently asked questions can highlight how hardware and software are successfully used in and out the school district.
- The process of designing such training begins with a needs assessment of where staff are in the basic use of technology, their comfort level in using technology in the classroom, and identification of curricula areas to be studied.
- The actual training would build on this information. At an entry level, an office suite of software including word processing, database, basics of telecommunications could be offered. This could be followed by software which enhances the curriculum. “How can the software enhance our curriculum?” and “How can
our curriculum be adjusted to take full advantage of the software offerings?” are questions which would be the central foci of this level. This phase of training would also encompass creation of multimedia presentations and such training could take place in groups or occur through tutorials. By means of e-mail, these educators would share opinions about software and curriculum with other educators. At the last level, educators would utilize their telecommunications skills to share lessons with each other and with educators around the world. They would be encouraged to explore the Internet for resources and materials which could become part of their everyday instruction.

Sell the Proposal

Selling the proposal is the most difficult and time consuming task. Nevertheless, this aspect of technology planning becomes more manageable when committee members represent a variety of teachers, administrators and community members.

It is important to point to studies and success stories of other schools in the nation that have already begun to use information technology. Their failures are also of great value in your planning. Students’ confidence levels are not just limited to computer use but also to other technologies. Presentation devices offer the opportunity for cooperative learning and are an economically feasible means of presenting information to groups of students. Demonstrations of students working using these technologies enhance the ability of your audience to understand what you are trying to sell. The integration of information technology into any school curriculum will enhance learning as it provides students with the necessary life skills for the 21st century.
General and Specific Issues in Applying Standards in Multimedia Development

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1 Introduction

Many audiences have a great interest in the development of standards for educational multimedia ranging from the developers, the users, the buyers, and the courseware, and it pervades virtually all levels of education and knowledge domains.

Producers and developers need access to criteria and standards to guide the development of high quality educational software based on sound principles of learning and cognition and our growing understanding of pedagogical design. It is also essential for developers to recognise the importance software engineering practices and principles in developing multimedia applications. In view of the mounting forces of edutainment, it’s critical that educational designers be on the forefront of defining standards, rather than leaving this important task to the marketing interests of the massive entertainment industry.

Multimedia standards would also benefit the purchasers and users of these programs, providing a means of assessing the quality of the many programs and products rapidly entering the educational market. The most commonly used evaluation methods (feature checklists and anecdotal reviews) are highly subjective and rarely based on systematic observation of learners using the software.

The purpose of this panel will be to present and discuss a taxonomy of issues related to the development of standards such as:

- cultural and institutional obstacles to developing standards;
- inadequacy of current methods of evaluating quality;
- the problem of transferring knowledge from research to practice;
- the difficulty of creating standards for widely varying audiences, tasks and learning contexts; and
- the feasibility of developing widely-accepted standards educating the consumer—helping users (and suppliers) to recognise good design getting consensus alternatives to standards.
The panel, through the process of negotiated meaning, will examine areas of consensus and appropriate processes for producing prototype standards that are widely accepted and valued; that can be flexibly adapted in terms of its implementation in different contexts; and that can be further nurtured through ongoing discussion by the relevant communities.

2 Lynette Gillis: The Position for Guidelines and Criteria for Selecting Quality Interactive Learning Materials

In recent years, the quantity of computer-based learning materials available to education and training has continued to increase, but there remains widespread concern about the quality of many of these products. With the rapidly growing number of CD-ROM and multimedia titles to choose from, educators and trainers alike are faced with the onerous and time-consuming task of selecting pedagogically effective programs to meet their teaching and training needs. This paper takes the position that evaluation standards or criteria are essential for helping groups and organisations recognise and choose high-quality programs from the many programs entering the marketplace. The presentation describes work being done in Canada to establish quality criteria to guide users and purchasers in their program selection.

Although most would agree that the best means of evaluating a program is to try it out with a sample of intended users, this is neither practical nor possible for most training organisations and educational agencies. These groups—lacking time, resources and often expertise—typically rely on magazine reviews to guide their purchase decisions. The accuracy of these reviews, however, is open to question, as magazines are often reluctant to publish negative reviews for fear of alienating advertisers.

The next common recourse is to use an evaluation checklist to assess program quality. The literature on software evaluation abounds with examples of checklists designed to assess the content, instructional design, technical reliability and operation of educational programs. These checklists, however, exhibit a wide range of problems that seriously curtail their usefulness. The individual criteria are rarely weighted or prioritised and often require a high level of evaluator expertise. Also, most checklists are designed to assess the tutorial form of learning, few address the newer multimedia forms emerging from constructivist and cognitive schools of software design. Similarly, most checklists fail to incorporate our growing knowledge of usability and human-computer interface design.

In Canada, the Knowledge Connection Corporation and the Continuous Learning Initiative launched an initiative in January 1996, with seven government and industry partners to develop “Guidelines for Selecting Computer-Based and Multimedia Training for the Workplace.” The guidelines and associated evaluation criteria are designed to help groups and organisations evaluate and select off-the-shelf software for training or evaluate software for purposes of customising it. It is also hoped that the guidelines will provide a useful reference for organisations preparing “requests for proposals” for multimedia development and evaluating programs while they are being produced.

The guidelines use a filter model for software selection. Two keys concepts underlie the model’s development. First, it is assumed that a “good” program is a necessary but not sufficient condition for effective training. Effective training requires that the program is:

1. appropriate to an organisation’s needs,
2. well designed, and
3. properly implemented.

To this end, the model proposes an evaluation method that assesses software in the larger context of its use. Secondly, the model reflects the pragmatic view that no CBT or multimedia program will be perfect. Selecting software involves making trade-offs. The model provides a time-saving and systematic means of evaluating software against key criteria and assessing the important trade-offs.

The model has four stages:

1. a match to the organisation’s requirements,
2. a general content, usability, and technical review,
3. a detailed instructional design and usability review, and
4. reality check with a user try-out.
Key evaluation criteria are identified at each stage. The project’s sponsors perceive this initiative as a first step toward defining instructional effectiveness in interactive learning programs and encouraging the development and use of higher-quality programs in the future.

3 Peter Ho: The Position for Better Software Engineering Practices in Multimedia Development

There is a belief that standards and better guidelines will somehow transform the multimedia industry into producing high quality educational software. Is this a realistic expectation? In an industry that is still “finding its feet,” one has to ask the obvious:

1. Are standards for the industry really necessary; who should be responsible for setting the standard; and what kind of standard ought it to be?

2. Will any standards ultimately work in an industry that is motivated more by profit than by perfection?

Standards are, in principle, a good thing to have. It provides a starting point from which to make qualitative (and maybe even quantitative) judgements. However, in an industry that is still developing, we need to ensure that standards do not stifle innovation and creativity. As such, standards should focus on the development processes that would result in quality products rather than just the content and the interactions of the product. It is perhaps too easy when we think of standards for multimedia applications, to concentrate on the visible component, but to do so would be to regulate the content.

A reasonable course of action might be to consult (or perhaps even use) the standards already in place for the software industry. Arguably, multimedia products are, in principle, no different to more general purpose software products—they are still in essence, just software. They have a development life-cycle that must include at the very least: specification, analysis & design, implementation, testing and documentation. Perhaps the provocative view of adopting software engineering practices and the use of an appropriate software standard would make an ideal basis for further discussion.

Finally, would having standards transform the industry? If we look at the software industry, can we say absolutely that standards have changed the industry? The software industry has always been reticent about adopting standards simply because there’s no motivation to do so. But yet the industry has matured. Perhaps the same fate awaits the multimedia industry.

Understandably this does not help institutions and funding bodies who are particularly keen to utilise standards to filter and to regulate the education multimedia industry. But will such actions bring about a broad change to the industry as a whole? Can we even predict what effects this will this have?

4 Martin R. Ramirez: The Position for Quality Standards in Courseware

Commodity markets fuelled by consumer acceptance and technological refinements have actualised the era of widespread authoring and publishing of multimedia software to be used in educational contexts. The proliferation of learning tools has even reached the traditional home electronics market and thus provides an opportunity for active augmentation of what is or is not found in today’s schools, particularly at the K-12 level. Publishers and indirectly, hardware vendors, are becoming increasingly more interested in developing criteria for products that will be successful in the marketplace. Concurrently, the buying public which includes schools, universities, faculty, and students would like economically successful products that deliver on the quality dimensions of effective learning. The aim of this panel is to explore the myriad of issues which impinge/intersect/compound the multifaceted development of quality courseware. On a logistical level, there is an interest in access and portability and the technical side of maintenance, more fundamentally, there is also the interest in ensuring that the quality of the content and the delivery mechanisms of that content are most ideally suited to the learner or fit for the intended use.

At a policy level, funding agencies as well as accreditation bodies have an interest in ensuring that there exists a set of quality standards by which to judge the educational core pieces of technologically-based proposals and the reforms that those produce.

The structure, extent and organisation of these standards has a profound effect on all of these constituencies and as such will yield a substantive audience to consider the feasibility space of the various alternatives.
Collaborative Inter-Class Teaching and Research Over the Internet:
Students’ Perspectives On the Research and Learning Process

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A perspective on collaborative inter-class teaching and research over the Internet

Background

Computers have become a motive force in the redesign of higher education. Since 1992 a project task force at West Chester University has been dedicated to integrating technology with collaborative teaching and learning by connecting distant university sites via the Internet to create a "virtual classroom". This interest grew out of participation in COMCONF, a distributed conferencing system maintained at Rensselaer Polytechnic Institute. The Comconf project suggested that implementing technology for inter-university cooperative education supplemented student learning by providing student-to-student and student-to-faculty discussions with distant sites. However, exploring windows of knowledge is intensified into an active learning process when one adds a collaborative component to computer-mediated communication in the classroom. Therefore, our goal has been to create not only a course that incorporates technology, but incorporates technology to create a collaborative teaching and learning model.

Collaborative Distance Learning Model

This model takes the view that traditional classroom settings, and especially classrooms restructured to incorporate technology, are more than places of information exchange and acquisition of knowledge, but are places where students have the opportunity to be active learners working together on a specific learning objective. This model uses the Internet as a collaborative tool connecting students in different disciplines at distant sites. Although course contents differ, psychology students at West Chester University and business students at University of California at Long Beach collaborate to integrate positions, ideas, and theories from their respective discipline's for a final research paper. To assist in the collaborative venture, the University of Wyoming provides writing assistants to aid students in determining and clarifying their ideas. All communications are made public through the "Clastalk" Listserv. The class runs for one fifteen-week semester.
In the first class meeting, students in their home sites (WCU and CSULB) are introduced to the structure of the course and placed into clusters of four. The second class meeting consists of E-mail, Listsev, Gopher, and Netscape training. Beginning with the third class meeting and continuing throughout the semester, clusters communicate with their partner cluster at the distant site and with the writing assistant assigned to their Internet-linked working task group. See [Treadwell, et al. 1995] for detailed information on the structure of this collaborative distance learning model.

Benefits of Collaboration in Distance Learning

This is an effective learning model where students of different disciplines, cultures, and countries learn to collaborate with students in different regions of the world. This model prepares students to be active learners and technically sophisticated innovators, who can adapt and prosper in the competitive world. The experience of working in task groups and collaborating with distant sites prepares students for real work environments by training them in negotiating and decision making skills. This technological linkage of distant sites makes it possible to incorporate the expertise of faculty and independent consultants not otherwise available to students. Likewise, students are not scrutinized, but encouraged to seek the outside opinions of others. As a result, students and faculty are exposed to different teaching and learning styles. Furthermore, this model breaks down not only boundaries between learner and instructor, and learner and learner, but reduces isolation between disciplines, divisions, and institutions.

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A director’s perspective of collaborative inter-class teaching and research over the Internet

Phases of Collaboration

Collaboration is this model's key element. The course utilizes technology not just as a vehicle for communication, but as an educational tool that teaches students to collaborate over the Internet. Collaboration is not easy, is not immediately achieved, and does not always have expected results. The writing assistants observed that collaboration over the Internet went through four phases: 1) making contact, 2) task clarification, 3) duty/role negotiation, 4) work, and 5) settlement or closure. Making contact consists of students familiarizing themselves to machine, and to people at home and distant sites. In phase two, students clarify their tasks. Some division of labor usually happens and maybe some scheduling and planning. Mostly, students ask a lot of questions about the task. Phase three, duty/role negotiation, consists of students determining who is doing what and how that is related to the collaborative project as a whole. Some individuals may take on roles not directly involved in the project, but may take on roles related to the group's interactions. For example, an individual may take on the role of cheerleader, providing the group support and motivation. In phase three, strict communication ends and collaboration begins. This continues through the phase four in which students concentrate on the work aspect of the project. With tasks clarified and role expectations determined, students more actively focus on the problem solving aspects of their project. Settlement and closure are reached in phase five. Students choose to stop, either because of time restraints or by mutual agreement, and the connection between the three sites is dissolved.

Future of Collaboration in Distance Learning

Future ideas for collaboration in distance learning include expansion of this model to other inter and intra university sites. The technology used for collaboration in distance learning can be expanded to include Inter-Relay-Chat and interactive video. This will expedite the clarification of task roles and accelerate the collaborative process.

Suggestions for Creating a Collaborative Distance Learning Course

This collaborative distance learning model can be adapted by students and professors of discipline who are committed to communicate and collaborate to meet their stated objectives. Suggestions for setting up your own collaborative distant learning classroom include: Use computing center staff as a resource for support. Use the same technology at all distant sites. Start with your existing class content. Adapt the collaborative distance learning model to fit your existing class content and process, don't alter class content and process to fit the...
"structure" of the collaborative course. Make the acquisition of knowledge only one of the objectives in the course. Simply acquiring needed knowledge will not see students through the course. Don't make the collaborative assignment an option. Students must collaborate to complete an assigned project--i.e. a 25 page paper. Time is crucial, make sure that class time plus overtime is the rule. Students need time to work through an open-ended project. Use multiple outcome measures to assess students' progress--it reduces anxiety and uncertainty about grades. For example, grades should be determined by a combination of exams, papers, and effort in collaboration. Don't buy into students anxiety. Students need to learn how to handle technological conflicts. Communicate often with professors at distant sites and work as a team. Students will take advantage of professor's mis-communications. Make sure that the class is structured by the professors, but led by the students. The professors take on the role of mentors rather than lecturers.

Adel Barimani, Director of Academic Computing ServicesCo-Director of Collaborative Teaching and Research Internet Project.
A technological perspective.

Technological Perspective

The "interactive collaborative teaching project" is a combined effort of two faculty members at West Chester University, and California State University at Long Beach. This project was designed for students and faculty to link classes, via the Internet to create a virtual classroom.

The Campus Wide Information System (CWIS) at WCU provides the West Chester University community with a completely new medium for communication and public relations. This new service provides the university with one central resource and location for all vital campus information and the connectivity to the Internet allowing students to work on such projects as the "interactive collaborative teaching project".

Having a presence on the Internet is quickly becoming a major tool for communication, public relations, teaching and transacting business for educational and governmental institutions. With more and more college students tapping into the Internet, this medium is quickly becoming an avenue by which students will seek information for their higher education/college projects.

The central user area, which is called the Academic Computing Center, contains 200 workstations. Over 1000 faculty and staff workstations are connected to the campus state of the art application servers accessing the campus software repository, e-mail, and Internet services. World Wide Web browsers have been installed on all campus workstations.

We currently maintain over 7,000 MS-Mail accounts on our servers. A number of faculty members have developed prototype courses in which all papers and other assignments are handled entirely via the electronic mail system. A few of the professors are even using an all electronic set of exams!

The Internet is quickly becoming an important teaching and a research tool used by the majority of faculty as an integral part of the curriculum at West Chester university. The next step in the process of collaborative teaching is to include the use of video and audio technologies over the Internet. We have engaged in an active role in testing these new technologies at West Chester University and in our classrooms.

Michelle Pole, Psychology Student.
A perspective on collaborative inter-class teaching and research over the internet as a student and a writing assistant

Perspective as a Student

As a student in PSY400 I expressed a gamut of emotions in reaction to our assignment. These emotions ranged from frustration, uncertainty, and anxiety to curiosity, freedom of exploration and discovery, competence and accomplishment. The traditional classroom experience is very predictable, too predictable perhaps. In this global classroom I found myself jettisoned into what was anything but predictable.
As a non-traditional student, I found this collaborative experience very much like the “real world” work environment. People with different personalities, work styles and motivation were thrown together, given basic instructions on the task to be completed, and then let loose on the Internet. More and more, this is how work is done, and students who learn this skill will have an advantage in the professional world.

One of the more difficult parts of this project was establishing working relationships with students in a Human Resources Management class from California State University at Long Beach. There was a real hesitation to establish this technological relationship because it seemed that it would be much easier to complete the research project independently. This stumbling block was eventually worked out, and I believe the time constraints for the completion of the project, along with the instructors monitoring the collaborative process over the Internet was the catalyst for this. This cooperative learning was beneficial and the interdisciplinary approach to the project helped me see my research topic without blinders.

In addition to working with students in California, each group in the class was assigned a Writing Assistant (WA). The WA was not an expert in psychology or leadership, but they were the people who forced us to clarify our ideas. The WA was an important part of the project. It is sometimes very easy to become unclear or too focused on a subject. Our WA reminded us to look at the subject from novel angles, not necessarily only the “expert” angle. Our WA forced us to be very clear about what we wrote, how we wrote it and she reminded us of who our audience would be and of the need to write for that audience.

All groups and WA’s communicate via “clastalk” and are able to monitor all of the other groups’ correspondence. It is helpful to view how other groups tackle similar problems and it gives others ideas on ways to problem solve. Eventually, after much resistance, I felt a camaraderie and built a good working relationship with my group, our WA, and the CSULB group.

Perspective as a Writing Assistant

Since taking the class, I have continued to stay involved with this project as a WA. For the past two semesters I have assisted groups in the process of interactive learning. From the perspective of a WA, I initially feel much resistance from the groups to include me in their work. There seems to be territorial behavior from all ends in the beginning of the project. Each group wants to work independently, without the help of a WA, or a group from across the country. So, in my role as WA, I initially work to integrate the groups and their ideas. This is not an easy task, and sometimes I have to just sit back and let them thrash it out until they realize that they can’t always have it their way. The groups struggle for quite some time before they actually begin to become productive. When they finally realize that they can’t work independently, the project begins to get off the ground, and some groups actually enjoy working with each other. There is much more give and take of information between the groups at later stages of the project. The goal of the process is a cooperative learning experience.

The global classroom is an exciting environment. I believe that more and more educators will be drawn to this mode of teaching. Computer technology pervades almost all aspects of life, a global classroom is one way to prepare students to enter into this way of life.

Erin Lynn Ross, Psychology Student.
A Perspective on collaborative inter-class teaching and research over the Internet as a student and a writing assistant

Research and Learning Process

The collaborative teaching and research project over the Internet is a refreshing approach to the learning process. It allows students from three different universities (California State at Long Beach, Casper College in Wyoming, and West Chester University) across the United States to collaborate and produce a research project. Each site is responsible for a different aspect of the learning process. The three universities communicate through electronic mail over the Internet. This allows students to focus on one another’s ideas and completely disregard potential stereotypes and biases.

Perspective as Student and Writing Assistant

The teaching and learning process over the Internet is a valuable learning experience. It allowed me to gain hands-on experience with innovative technology and required me to learn how to work with peers. It encouraged me to branch out and reach beyond the usual means in order to conduct research. The collaborative
Internet course allowed me to work at a comfortable pace, my ideas were taken seriously by instructors and peers, and through this experience I learned how to work with peers and writing assistant in a group setting.

As a writing assistant I assist students who are conducting research by challenging their ideas and methods. This is essential, for it gives students practice in taking input from peers without feeling judged. Additionally it helps clarify their research ideas giving focus to their collaborative project.

Results of Collaboration

Rating Emergent Leaders: Bias Differences Between Mixed-Sex Groups and Same-Sex Groups, is the title of the research we conducted [see Pole and Ross, 1994]. This study examined leadership emergence in Resident Assistants at West Chester University in Pennsylvania. This study concluded that the removal of normative influence from a group would effect the emergent leadership patterns in mixed sex and same sex groups. This research has been presented at two symposiums and is currently being reviewed for publication.

It is my position, that this collaborative distant learning model achieves its goals to give students valuable research experience comparable with the true working world. I highly recommend this learning environment to any student, particularly those planning to continue their education.

References


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SHORT PAPERS
Development of an Electronic Teaching and Learning System for Undergraduate Degree Courses

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At Athabasca University, the Virtual Teaching and Learning environment (ViTAL) has been developed using Lotus Notes, a software package that has been used widely in businesses for coordination, collaboration, and messaging but which has not been applied widely for educational purposes. In this paper, the key processes and elements in the development of ViTAL are examined: hardware and software selection, system functionalities and interface, and the maintenance of print courses alongside electronic courses.

The most important design decision for developers of the ViTAL system was identified at the outset as the separation of on-line activities for students and faculty from off-line activities. A learning system that would be exclusively or mostly carried out on-line with a server computer would have significantly higher infrastructure and operating costs associated with it than one for which on-line activities constituted only one of many electronic activities. With a target student body of several thousand, the designers chose Lotus Notes as a development and delivery environment because it features the unique "replication" process that ensures that on-line activities of students and faculty would be minimized. As a result, the use of the system by either a faculty member or a student can be estimated to be only a few minutes per day, even though intensive use is made of the system for educational purposes. The designers also decided to consider only those software packages that had the support of a corporation with wide acceptance in the information management marketplace. Although the developers wanted to have the flexibility of designing and changing the system, they did not have the human or financial resources for making major design changes to software and hardware.

The ViTAL system provides study materials, student conferencing, access to the Athabasca University library and other databases both within and outside the University, assignment preparation and submission, help facilities for both course-specific and general inquiries, course evaluation, and networking with students and faculty. Each of these activities has been developed as a Lotus Notes database. For the student, the environment is easy to use and intuitive, incorporating point-and-click iconic interfaces. To participate in a learning conference, for example, a student double-clicks on the icon for the conference, double-clicks on the conference topic corresponding to her progress in the course, reads about the topic, and then enters a response on a form that appears after an on-screen button is chosen. After closing the conference area, the student chooses "Replicate" from a pull-down menu, which begins the process of having the student's computer communicate with the University server computer. After replication is completed, the student can read responses from other students in the conference. The view for such a conference resembles that of an Internet news group.

The ViTAL platform provides the capability of incorporating the many microcomputer application software packages that are available for learning purposes. For example, some courses include an integrated Authorware application as part of the presentation of learning materials. Students may submit assignments after using the "built-in" Notes wordprocessor but may also attach their own wordprocessing, spreadsheet, or presentation files. The designers of the system have ensured that all functionalities for students remain as part of an integrated learning environment. This should provide for coordination and collaboration throughout the University, in both course-specific and non-course specific activities.

As a distance-education institution that has until recently focused primarily on the development and delivery of print courses, the transition to electronic development and delivery has been an important issue. The ViTAL version of study materials are developed to function concomitantly as the electronic source file for the print version of the courses, which continue to be offered in traditional correspondence mode. Future development of ViTAL will be in
the following areas: access to the World-Wide Web from within the learning environment, desktop videoconferencing, and remote application access.
Multimedia Training in the Mining Industry - Collaborative Development in Customised Projects

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The Curragh Multimedia Project - a Collaborative Venture

The Curragh multimedia project came about as part of Curragh Queensland Mining Limited's strategy to develop a skilled workforce that would contribute to productivity at the mine site. Multimedia was chosen as the training medium because it allows for the supply of consistent information and the standardisation of training, which solves a major problem in the training of heavy vehicle operators in the mining and other related industries. The packages also cater for shift workers as they provide a self-instructional, self-paced training medium. The package is designed to cater for a range of educational levels, a major consideration in many industry training environments. Material in customised multimedia packages can be made pit-specific and updated to ensure that the information presented to users remains current and adheres to relevant legislation and competency standards.

As is common with many industry organisations, Curragh mine did not have the staff or expertise to develop the training package themselves and thus needed to find an external developer with the appropriate skills to participate in the development process. As the result of a tender process, the Interactive Multimedia Unit (IMU) at Central Queensland University was selected as the developer. This kind of collaborative relationship between industry and a tertiary education institution to develop training materials calls for close communication between all parties if the outcome of the project is to be successful. It is particularly important that the client has a clear understanding of the roles and responsibilities of all those involved in the development process. This is even more so in the case of third party development where a manufacturing company may be providing a training package for a custom built machine that has been purchased by a particular mine or industrial company. Staff from the IMU worked closely with staff at Curragh mine to produce the training materials. The development team included content experts, (generally the most efficient operators), the training officer, instructional designers, multimedia courseware developers and graphic artists. On some projects, training officers from manufacturing companies where these companies have also been involved in the development of the training materials have also formed part of the team. All of these individuals have an important role to play in the process. Additionally, the instructional designer is an essential part of the collaborative process, providing an interface between the subject matter experts and the programmers and graphic artists. Good instructional design is considered to be critical to the success of effective multimedia training. While much existing multimedia training material for industry purposes is glossy and attractive, it can lack instructional design and thus serve little instructional purpose.

There are many opportunities for collaborative developments in industry. Collaboration in development can ensure both a high quality product and a spreading of costs. However, it is important to note that any collaborative venture needs to be carefully negotiated, with all parties having a clear understanding of their rights, roles and responsibilities.

Critical success factors in the development of collaborative multimedia projects for industry include:
• close consultation with personnel from the client company
• close consultation with all parties if a third party is involved
• the inclusion of operators or other workers in the development process
• quality instructional design
• relevance to the users.
As organisations increasingly seek to improve productivity and efficiency within the workplace, the demand for effective training packages will continue to increase. Collaborative projects between industry and education providers can ensure successful outcomes.
Antecedents

The number of users at the UAM University, Campus Azcapotzalco's Computer Department, grows day by day, resulting the increasingly difficulty to lend the advise care they require and deserve. We thought users could train themselves in diverse computational topics. To fulfil this objective, we began to develop the idea of interactive courses, so the people may learn about their themes of interest using Internet, from their own computer and at any time they wish.

Current State

At the time we are building the first set of courses. Every course have a thematic index, and each theme can be accessed by clicking the hyperlink. Inside the lesson texts there are some marked words and images, which conduces to more information about them. In some cases, when an historic subject is treated, the user can access a time-line to get information about a particular period, by clicking on the corresponding section of the line.

Following the courses' indexes, there are small lists of interest points, that links to more information about the treated topic in other Internet servers. Each course has also an automatic test, which return the user's obtained note. Lastly, an e-mail address is mentioned, with the purpose to clean out any doubts. This mails to the course's assigned advisor.

Each course may have as prerequisite one prior. Of such manner the users can really form themselves with a programme in the wished discipline.

Future Improvements

It will be integrated a discussion group per course, to interchange knowledge, comments, questions, etc., between the subscribers. We are also working on the including of audio and videoconferencing, so the students and the advisor could have a more strong contact.

Conclusions

When developing this project we noticed this tool can be really useful not only for our users. It opens the chance of integrate any discipline and makes possible that any person to take the courses, at their offices or at home. To browse the project advances, visit us at http://www-azc.uam.mx/eduanet.html.
An Interactive, Simulated Experiment for Biochemistry and Molecular Biology Students

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Growing class sizes and declining resources in tertiary education have made support for traditional wet practicals increasingly difficult. This has lead to their replacement by "dry practicals" which are little more than data analysis on paper. In an effort to address the reduction of resources and extend the design of undergraduate experimental work the Division of Biochemistry and Molecular Biology at the ANU has developed a series computer based laboratory exercises and research projects. These are undertaken over two weeks in usual laboratory sessions.

The software has two main parts - an interactive tutorial and a simulation of the data collection process. The software also includes a reference section, calculator, notepad and log in facility.

The program begins with an illustrated and animated introduction to mitochondrial metabolism and ATP synthesis providing reinforcement of concepts met in lectures and tutorials. This is followed by an exercise in calculating the quantities and volumes of reagents for media preparation which the students must complete before moving to the next step. Feedback and optional hints are provided to assist them. The final section of the introduction describes the set up and operation of the oxygen electrode through illustrated text and QuickTime movies.

The second part of the program emulates the collection of data in the traditional laboratory-based practical. Second year students are guided through a set of six simple experiments which illustrate the oxidation of various substrates by mitochondria and the effects of various inhibitors and uncouplers. Rates of oxygen uptake can be calculated from the recordings generated on the screen. This version of the simulation is aimed at biochemistry students studying bioenergetics for the first time.

A more advanced version of the simulation provides access to the full range of menu options allowing the selection and addition of mitochondria and reactants in any order or quantity. This is used by third year students to design their own experiments with the program responding realistically to virtually any imagined assay that can be preformed with isolated animal mitochondria. A series of unknown compounds has been built into this version and students are required to design a set of experiments which will lead to a positive identification of the compounds.

The software has been trialed with groups of students at the ANU, the University of Western Sydney - Nepean, and James Cook University. Evaluation in the form of questionnaires and group discussions was carried out with the assistance of the Centre for Educational Development and Academic Methods (CEDAM) at the ANU. The results were very encouraging.

The questionnaires indicated that "When comparing the instructional software in this unit with others that the students have used, 74% of the students rated it as excellent or very good whilst 94% either agreed (52%) or strongly agreed (42%) that the software in this unit was a valuable learning resource. Overall comments were laudatory of this innovation...". In a group discussion, held at the ANU, students were highly positive about the value of the animation for improved visualisation and the opportunity to conceptualise the process without the pressure of data collection. More importantly, they felt that the computer simulation provided a more relaxing and less stressful learning environment than the traditional laboratory exercise.

We recommend that the simulation be used in conjunction with a demonstration of the real equipment and material which would allow students to appreciate the technical difficulties which the simulation removes.

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The Relationship Between Linear/Nonlinear Navigation and Linear/Nonlinear Mental Models of Hypermedia Environments

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Overview

We borrow from the field of cognitive psychology one line of thinking: at a metacognitive level (Flavell, 1976), if research-participants identify certain features of a hypermedia environment as being linear or nonlinear, will their navigation of a hypermedia environment (Jonassen, 1989) parallel the relative degrees of linear and nonlinear awareness? This study is a follow-up to two previous studies. The first study (Reed, Ayersman, & Kraus, in press) determined the frequency of linear and nonlinear mental models that research-participants identified in a hypermedia program. It was found that, when the context was weak, there was an even distribution; when the context was strong, there was a greater discrepancy, clearly in favor of the linear mental models. The second study (Reed, Oughton, Ayersman, Ervin, & Giessler, in press) determined the actual navigation patterns when another group of participants engaged a hypermedia environment. It was found that they took more linear steps than nonlinear steps.

Methods

Thirteen students were the research-participants in this third study. Prior to the Context-Weak exercise, they worked with the Ultimedia hypermedia program for three one-hour sessions. Prior to the Context-Strong exercise, they worked with the Ultimedia environment for four one-hour sessions. For both the Context-Weak and -Strong exercises, they were asked to identify which of the four mental models (semantic network, concept map, frames/scripts, schemata) was represented by each of the 19 tools, commands, or features of the Columbus program (Weak exercise) and the 19 tools, commands, or features of the Ulysses program (Strong exercise). Two weeks later students engaged in another hypermedia program; we employed the Stack Monitor program which records the cards they access and the sequence of card-access. We then analyzed each step and classified a step as linear when it was the next sequential card and classified a step as nonlinear when it was not the next sequential card. The percentage of nonlinear steps was also calculated since the students could take varying numbers of linear and nonlinear steps.

Results

Of the navigation-step measures, the most consistently reliable one was the percentage of nonlinear steps. We found significant negative relationships or trends between percentage of nonlinear steps and (1) semantic networks (p = .07), (2) frames/scripts (p = .04), linear models (p = .04), and information-structure models (p = .09) when the context was weak. We found significant positive relationships or trends between the percentage of nonlinear steps and (1) concept maps (p = .08), (2) schemata (p = .02), nonlinear models (p = .04), and user-practiced models (p = .09) when the context was weak. We found significant negative relationships or trends between percentage of nonlinear steps and (1) semantic networks (p = .07), (2) frames/scripts (p = .01), (3) linear models (p = .04), and (4) information-structure models (p = .06) when the context was strong. We
found significant positive relationships or trends between the percentage of nonlinear steps and (1) schemata (p = .02), (2) nonlinear models (p = .04), and (3) user-practiced models (p = .06) when the context was strong.
1. Introduction

If we take a look to multimedia applications, their composition is defined by a multimedia knowledge (made up of text, images, video, audio, databases, etc.), an user's interface (which shows to the user multimedia knowledge in an attractive way), a group of interactive functions (allowing the user to manage the multimedia information through the interface) and network functions (that allow to connect the client with servers in a distributed environment).

Our system is highly dependent of the source nature (educational video) and it is oriented to solve the necessities at level of queries by content desired by students. Few years ago, the main problems were the storing of huge amount of information and the hardware limitations for real-time visualisation. Nowadays these limitations are being overcome by new video compression/decompression techniques and network technologies. At the present, the key points are the difficulty to classify, store and retrieve video sequences based on content criteria when they deal with large video databases. Our aim is to provide a new digital video data model with content-based access to alleviate these problems and to motivate an extensive use of video resources for distant education.

2. Data Model

The methodology of educational video information system consists in using a defined model where the human intermediary (teacher) interprets and transcribes the semantics of the video sequences over this model. Nowadays, the computer-based transcriptions using automatic techniques from computer vision are not satisfactory enough.

The data model that we propose for indexing educational video data is structured as trees and follows the segmentation of shots, scene and segment presented by other researchers’ work.

3. Architecture

The system architecture we propose is composed of:
a) Relational databases containing metadata about video.
b) Archive servers to store the video data.
c) Annotation-video-interface for indexing.
d) Query-video-interface for content-based retrieval.
e) The metadata files define attributes and relations among these entities and they also contains concise information about the location of the data to be retrieved. The advantage of the metadata approach is that it allows the user to examine the contents of a database without having to retrieval large data objects.

The interface consist of two modules. An annotation-video-interface which can be used to put keywords, comments, proposal exercises, recommended lectures and so on in video segments. The annotations specify video sequences information for the automatic generation of a video library indexed by content. And a query-
video-interface which can be used to extract the relevant segments of video that satisfy the specific query condition.

4. Implementation

We developed a graphical menu-driven user interface which offer queries by keywords and combination of them offered by the index of the DB (generating no empty answers). The interface was designed in such a way that an user can use it without knowing neither the database's details nor any query language. As result of our experiments with the system we realised that the teacher's extra work for indexing and metada updating is relatively small compared to the time we took just to compress the sequences in a Quicktime file. This demonstrates that for educational purposes, where the contents of the topics are well defined previously, our indexing techniques have shown to be adequate. When testing the system with the students, they understood very rapidly how to use the program to construct complicated queries in order to retrieve desired lectures' segments. Indeed, they were motivated and satisfied with the possibility of attending the desired lectures as many times as they wanted.
Towards the Definition of a General Model for the Transfer of Knowledge in Multimedia-Based Learning Systems

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A model called EMI (Educational Measurement Instrument) for the interpretation of the skill acquisition and learning process of an undergraduate computer-based learning tool has been defined. The purpose of the model is to identify particular behavior patterns which may be measured qualitatively and quantitatively. This is done by defining variables which we believe affect the learning and skill acquisition (such as Cognitive Taxonomy as well as Field Dependence/Independence and Reinforcement Units). The concurrent introduction of cognitive studies allow us to interpret the measured results in a multidisciplinary (i.e. artificial intelligence - education - cognition) fashion.

This elaboration of the model is based on structured observation of the plans autonomously designed by the student as he/she solves tangible but non-monotonic problems during the use of a virtual education prototype called Visual GUIdes. The current Visual GUIdes is a piece of software which features computerized simulations of mathematical abstractions and programming procedures typical of an entry-level Datastructures course.

These simulations are described by means of a hypermedia graph which defines the possible routes available for problem-solving. Each of the situations is modeled as a complex network of nodes which form the virtual space through which the student navigates in his/her process to solve the current problem. Each node in the hypermedia graph is a window with locally or globally (i.e. world wide) placed information. Some of the information is static text, while other is made up of multimedia, and still other of computer-generated simulations of real-life phenomena.

The course week starts in an initial knowledge state. This state holds a set of prerequisites which are obtained from the mental state and knowledge corpus obtained by the previous week and lab. The purpose of the week-long work will then be to reach a final state, with the corresponding change in his/her knowledge status and knowledge corpus. Being at one of the final states means that the student will have obtained credits for the next week. The cumulative and progressive acquiring of these credits will eventually allow the student to pass the course. The inability to accumulate the credits in a predetermined but flexible timeline will result in course failure.

Such a system can be represented by four components: an initial knowledge state, a set of intermediate (knowledge acquisition) states, a set of Learning Processes, made up of (intermediate) states and a set of available terminal states. The states eventually form any partial order (i.e. internal graph path) in which the students will acquire knowledge, while the Learning Processes represent the educational instrument, or operator that modifies the knowledge pool and corpus of the student. The [final] topology of the path tells us the particular needs of the individual, and his/her way of solving the problem, thus providing a guidance/feedback element for the definition of new educational profiles and academic curricula. In order to assure the proper measurement of the increase in expertise, skill and information sources by the student, we provide a Transformational Operator, or Learning Process, which takes as its input the current knowledge scheme held by the student, plus his/her currently defined student profile, and modifies it forming a new, enriched scheme. The transformation is based on the particular approach taken by the student while solving the problem and other performance/educational parameters.

The EMI model is a conceptual foundation on which we base our theoretical frameworks in order to develop educational tools such as the Visual GUIdes. Currently this model is used to define the DataStructure virtual class and can be extended to other computer-based learning tools.
The Development of a Computer-Based Academic Tracking System with PowerBook and PowerTalk

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Introduction

The development of community-based medical training sites away from the main campus has raised faculty concerns about assessment, tracking and didactic experiences for students at the distant sites. To address this concern, the Kirksville College of Osteopathic Medicine (KCOM) has initiated the development of a computer-based academic tracking system to monitor regional medical preceptors' and students' clinical activities. This tracking system was established with Apple PowerBook computers and PowerTalk software. The development of this system illustrates a successful remote communication solution and the potential of using Apple technology for monitoring community-based medical training.

Development

PowerTalk system software and an existing 1-800 phone line were used for the "pipeline" for the remote communication system. A series of computer applications, including a log program, a log-management program, and an academic database were then developed. Students are provided with PowerBook computers with internal modems. They use the log program to record clinical activities while on clinical rotations around the nation. At the end of each rotation, students use their PowerBook to connect to the remote communication network and download clinical data through the PowerTalk software. A secretary using the log-management program downloads student data from a dedicated PowerTalk Mailbox into the academic database. The academic database is then used to categorize the data by rotation site, clinical exposures, and preceptor. This information can then be used for evaluating the quality of training at the remote campus sites.

Results

The Class of 1997 was the first group of students to use this technology. To date 126 of 131 students have utilized the communication system. The log program is the most common use so far. The utilization of this program has significantly decreased clerical time in tracking student experiences while on rotations. The next phase of the program will be to utilize the data from the database to plan future clinical experiences for students at the community-based training sites.
Using Virtual Reality Technology for Learning Design Skills

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Object Technology (OT) is a new method of building software systems that uses a modular programming approach. This is not just a new way to program, but a new way for people to think about, and design for, problem domains. Andersen Consulting's Object Modeling School was designed to meet the cognitive challenge of educating Andersen consultants about OT. Two significant challenges for teaching OT design skills are helping learners understand abstract concepts and helping them understand dynamic complex systems. Visualization techniques have been proposed to help overcome these abstraction problems in OT [Carpenter-Smith, et al., 1994].

The dynamic complexity in the execution of OT program events is significantly different than traditional approaches to programming. The learners must shift from keeping track of a sequence of procedures to thinking about their designs as a collection of communicating entities. Building this new mental model is a key component for learning design skills. A learner's mental model can only be revealed by providing opportunities to make decisions which translate into actions. Discrepancies between the learner's mental model and the true nature of the system are realized only through feedback resulting from the learner's actions.

Traditional approaches to teaching design skills have learners diagram and document design elements and later write programming code to test the design - long after design activities are done. PC-based virtual reality technology has transformed the learning environment for these design skills. A tool was created which provides the learner with a two dimensional flow-charting tool and three dimensional browsing and interaction space. Learners in Object Modeling School create objects which are displayed as three dimensional solids. These graphic objects communicate all of the fundamental concepts of OT (e.g., data are shown encapsulated in behavior layers; collaborating objects are linked by directional pipelines). The interactive three dimensional graphics make the abstract concepts of object modeling visible and tangible. To address the issue of complexity, learners are able to test their model design by “walking” through their virtual model or observe their system in action from a third person vantage.

The object modeling virtual reality tool was tested with forty participants in Object Modeling School. Two expert OT modelers volunteered to perform a blind review of the participant's object models who used and did not use the tool. The results indicated that models designed with the tool were significantly more complete and better documented by the learner. When learners were asked how many iterations they were able to complete, the VR tool group were able to iterate through their design an average of six times compared with the two iterations of the non-tool groups. When non-tool learners were asked how much time should be devoted to conducting the school they estimated an average of eight days while VR tool users estimated only four days. In fact, those using the tool had completed all of the course material by the beginning of the fourth day. In summary, we have demonstrated significant learning and performance enhancements provided by virtual reality software for the development of OT design skills.

References
Large-Scale, Hypermedia-based, Course Legacy Systems

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Introduction

This paper outlines the development of a paperless student submission and course legacy system implemented using the World-Wide Web (WWW). During the course of a semester, students must generate two electronic slideshow presentations and three papers as part of three projects. All five requirements have been altered so that they are submitted and graded on-line using the WWW. Furthermore, these student submissions become part of the course legacy system so that future students can use the papers, slideshows, and the multimedia components of the slideshows from previous students in their submissions. The slideshows, papers and multimedia components of the slideshows are all indexed and can be searched on via a course WWW search engine. The course legacy system was an integral component of the CS383 hypermedia courseware. It provides a digital library of student papers, multimedia slideshows, and the multimedia components used to build the slideshows. As of February 1996, the legacy system consisted of over 275 student presentations or papers from previous semesters.

Methodology

Before the beginning of the semester, instructors build a link to each student page based on the student's course unique number. The instructor also creates a directory to hold each of the submissions and sets the directory permissions so that the students can write and delete to the directory. On the first day of class, the instructor randomly assigns the student identifiers and provides the students with the following guidelines. Each student can design their WWW page as they desire. There are no names on the paper or the slideshow. The papers and slideshows are identified by student's course identification number. Students can submit their papers or presentations at anytime. However, at the due date and time, the instructor will lock the directories so that late submissions require coordination (and assignment of appropriate penalties) with the instructor. During the course of the semester, the instructor will annotate a grade as well as comments on each paper. Students get their grades through the annotations and the results, while anonymous, can be shared with other students.

Using this methodology, paperless submissions are mutually beneficial to both the instructor and the student. Professors gain an ever-growing digital library of course resources that can be easily maintained and enhanced with little impact on instructor load. Student presentations and papers constantly improve due to the ever improving course digital library. The students gain experience with the WWW, the Hypertext Markup Language (HTML), digital libraries, and hypermedia courseware. Together, paperless student submissions, course legacy systems, and the WWW form a powerful tool in the arsenal of the modern professor.

[1] The views expressed in this paper in no way express the official position of the United States Military Academy, the US Army, or the Department of Defense. All insights are the author's own.
An Intelligent Multimedia Tutoring System for Quality Control Training in the Food Industry

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In this paper we describe a computer program that combines Artificial Intelligence (AI) techniques with Multimedia technology for the education of Quality Control in the Food Industry (QCFI). The computer program can be considered an Intelligent Tutoring System [McCalla 94] with a multimedia environment [Chen 94] for the domain of QCFI. The Intelligent Multimedia Tutoring System (IMTS) has the goal of training new personnel, for the Quality Control lab, with the microbiological and chemical techniques that are needed to perform an evaluation of the quality of the food manufacturing process. The goal of the Quality control lab is the application of the minimal number of microbiological and chemical techniques to the samples of food extracted from production lines, so as to have an evaluation of the quality of the production as quickly as possible. The IMTS also teaches to the new people in the lab the logic behind a decision on the quality of the production. The IMTS simulates a human training expert in this area in the process of teaching QCFI. The computer program contains the knowledge of the human training experts expressed as rules and facts (knowledge base), and uses as a tool of reasoning the inference engine of Prolog.

The process of teaching this domain is difficult since it requires a good background on Chemistry and Microbiology [Castillo & Melin 94]. In this IMTS it is assumed that the people have the required prior knowledge mentioned above. When a new person uses the IMTS, he or she enters an individualized learning process of the QCFI domain. The IMTS maintains, for each student, all the relevant information about the learning status of the students. Also the IMTS monitors the actual learning process of the students. The learning process, considered in this IMTS, consists mainly of four steps: 1) Acquiring the basic concepts of the QCFI, 2) Learning the methods of application of microbiological and chemical techniques to the samples of food, 3) Learning the methods of identification of possible harmful microorganisms or toxic chemicals based on the results of the techniques, and 4) Learning to evaluate the quality of the production based on the identifications of microorganisms or chemicals from the samples of food. The IMTS has the responsibility of giving to the users the best possible understanding of QCFI. Our prototype IMTS uses AI techniques [Bratko 90] to improve the efficiency of the learning process described above and also to evaluate the level of understanding of the students of this domain. The use of AI techniques enables the right use of the knowledge of the human experts for training in this domain of QCFI. Also, the use of multimedia features enables a very interactive user interface for the IMTS, which in turn results in a very motivating system for the students to use.

References

A Learning Activity Development System on World Wide Web

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1 Introduction

In this paper, we proposed a development environment to free a teacher from the difficulties of communication software handling and data management while developing learning activities on World Wide Web. A Learning Event Description (LED) language is devised for teachers to specify their learning activities and styles. Our system will generate the required learning system according to the LED specification. By using LED language, a teacher can define a cooperated learning environment according to his/her requirements without concerning how to program the environment. Therefore, designing learning activities by using LED can be as easy as designing courseware by using HTML.

2 Basic Concepts and System Overview

The basic concepts of our system include activity, role, event, trigger, pool, and hypertext. An activity is composed of a set of roles, a set of triggers, and a set of events. To define an event, a user should define its: (1) notice, (2) form, (3) temporal condition, (4) pool name and (5) node link description. The notice part describes the explanation of this event. The form part describes the information required to be submitted back. The temporal condition part has two purposes: to define when the event should be completed, and to describe the partial order of events in an activity. An event needs to assign the name of a pool to store all the information submitted back by all the roles. The information submitted for an event by a user can be viewed as hypertext by WWW.

Events are initiated by a trigger. Triggers make the system to do some actions(events) automatically whenever some situation occurs. A trigger contains two components: trigger condition and trigger action. The trigger condition indicated when the trigger be activated. The trigger action indicates what to do when the trigger condition was satisfied. A role is composed of various triggers. Hence, a user may be assigned to a particular role in an activity.

3 Implementation

A teacher can use LED language to describe learning events. A LED language compiler will generate corresponding CGI programs which can be run on WWW server. The language was implement in a SUN workstation with NCSA httpd as WWW server and Ingres database system [Zinky, Everett & Hawbaker, 1992]. The generated CGI programs were written by Perl, which can also access Ingres database system directly. The distance learning system had been used for learning programming C in the course "Introduction to computer science" since last year. The discussion and homework were available in the Universal Resource Locators(URL): http://dbweb.csie.ncu.edu.tw/~kant_c/english.html.

4 References

A Script-based Development Environment for Instructional Games

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Introduction

We present an instructional game design environment. On this environment, an instructional game designers can focus on script planning and how to integrate a game with learning materials without considering details of computer programming. Two factors are considered: game script, and learning material structure. A model of game is devised to be used as the basis for the environment. By using the environment, the development time of an instructional game can be reduced.

Model of a game

We developed a model of a game. The purpose of this model is that a game designer can use this model to design a game script and then a rapid prototype system can generate this game from the description. Therefore, a game designer can only deal with the game script design without considering how to program the game.

The structure is similar to a program which has a network of subroutines. The navigation from a frame to another frame in a game is like a subroutine call in programs. Is-Part-Of and connected are two kinds of relationship between two frames. Is-Part-Of relationship represents that a frame (child) is part of another frame (parent). If two frames has a connected relationship, it represent users can walk from one frame to the other frame. In a frame, objects and roles are put at the initial position on the background in the beginning. Objects are static that can be deleted, carried by the leading role, or created. A role is described by its display, status’s, and behavior. The display of a role includes the graphic display when this role is static, and the animation display when the role is moving in each direction. A status is a variable that records the situation of this role. The behavior of a role is described by a state transition diagram, events, and next position.

Integrating learning materials with a game script

To support the developing of instructional games, the actions in a game script are categorized into four class:(1) pure game action, (2) tutorial action, (3) exercise action, and (4) test action. These description is appended to description of actions in the game script. It is used to check the consistency between learning material dependency and game script dependency. The description about learning material structure is stored separately. However, the links between the learning material structure and the game script stored is stored in both places.

Implementation

A learning hierarchy editor is implemented for user to enter the structure of learning material and the planning of the game. For game developing, we develop an environment based on our game model. The information of the instructional game script is stored in a Microsoft SQL server. The learning hierarchy editor, object/role defining tool, and event defining tool are developed by Visual Basic. After these works finished, a prototype game will be generated.
Assembling the Double Helix: Development of an NCTM-compliant Interactive Mathematics Learning Environment

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The National Council of Teachers of Mathematics (NCTM), in concert with the American Mathematical Society and the Mathematical Association of America, has constructed a set of revised curricular, instructional, and assessment standards for mathematics instruction. The NCTM Standards is a collective term describing the following three publications: [NCTM 89], [NCTM 91], and [NCTM 95]. The new standards are gaining wider adoption in schools and, due to their new emphasis, may make print texts less and less effective as pedagogical tools. An advanced interactive computing environment, which involves a synergistic combination of the traditional teaching method and the insights embodied in the NCTM Standards, is currently under study. Based on the “Double Helix” model, we have designed and implemented an interactive multimedia teaching/learning environment [Chen et al. 95] for mathematics for grades 7-12 and beyond. An underlying software engine constantly monitors the student's activities and passes messages between the two strands. The interaction transactions are recorded and passed to other engines (assessment and tutoring) for further processing. It provides a student-centered environment suitable for: (1) developing solid basic skills through individual active exploration and interpretation, and (2) supplying resources to facilitate collective learning as recommended by the NCTM Standards. The seamless integration of these two interacting sub-environments is expected to enhance learning efficiency.

References


Planning for the Air/Water Projects was initiated in 1990 with the first student-to-student interactions taking place in 1991-92 [Clayton, Campbell, Knezek, Moore and Christensen, 1992]. Since the project's inception, five cycles of fall-planning, spring-implementation for Internet-based, thematic, elementary school curricular exchanges have gotten underway. Participation has grown from 8 classrooms in 3 nations in 1991-92, to 44 classrooms in seven nations in 1995-96. Two curricular guides have been compiled based upon model project participant practices and published by the Texas Center for Educational Technology.

Each year the Air and Water Project activities have operated on a fall planning, spring implementation schedule. In order to better accommodate school year schedules in Northern and Southern Hemispheres, the dates for student activities have been further restricted to February - April. Chronologically, this process proceeds as follows: 1) A call for participation is typically posted to various Internet information servers in October; 2) Schools that meet the posted criteria are accepted on a first-come, first-served basis.; 3) Classrooms are grouped with others in remote geographic locations based on interest in Air or Water; and 4) Teachers at sites within a group are encouraged to interact with each other in preparation for the formal initiation of project activities, with their students, in February.

During the classroom exchange portion of the project, students gather information to share and compare with the studies of their international counterparts. The curriculum is divided into four modules which are based upon an initial framework from New Zealand. Each module sets forth a specific topic and guidelines. Each teacher then approaches these topics using his/her own creative instructional style and lesson plans.

Data has been gathered to demonstrate student learning takes place as a result of participation in Air/Water activities [Christensen and Knezek, 1994]. Attitudes toward the peoples of other nations may also change as a result of participating in Air/Water activities. Forty-nine U.S. third- and fifth-grade students completed a semantic differential rating scale with "New Zealand children" as the referent, in 1992-93. A subsequent factor analysis of the data indicated that the items clustered along two dimensions: Kindness/Niceness/Friendliness and Courage/Beauty/Strength. The major findings from pretest - post test comparisons of semantic differential ratings were [Christensen and Knezek, 1994]: 1) Attitudes of U.S. students toward NZ children changed slightly; 2) Profile of responses shifted: highly positive => neutral; 3) 16 of 18 items became less positive (p=.0007); 4) Two factors (dimensions) were measured; 5)Trends were toward less positive ratings on each (NS); and 6) 5th graders changed more than 3rd graders. These findings were interpreted as meaning U.S. children had unrealistically-positive perceptions of New Zealand children before project activities began, and possessed still positive but more realistic attitudes by the end of the e-mail exchanges.

When children involved in the Air and Water Projects were asked to give highlights of the project, they mentioned reading, writing and learning about their friends in other countries. In addition to gaining knowledge about content, the students learned a great deal about other cultures as well as their own.

Five years of Air and Water Project activities, along with findings from many other similar projects, have demonstrated that Internet-based, global interactions are viable and perceived as useful by educators and their students. The most pressing issue seems to be how to accommodate requests for ever-greater participation without over-burdening the existing low-budget support infrastructures. The approach we suggest in retrospect, looking back on the Air/Water Projects, is not unlimited expansion, but rather cloning. The educators involved in Air and Water have produced innovative variations on a theme within their own contexts and collaborative environments. Others can undoubtedly follow this approach as well.
References


The five-year project which this paper outlines is an on-going attempt, already in its second year, to study issues critical to the development of effective interface design for users in the Far East. The ultimate goals of this project include the development of a series of guidelines, standards and tools for development of more aesthetically and ideologically agreeable interfaces for use in pedagogical applications. It is the author's hope that these interfaces will enable students, educators and professional developers to produce more effective educational multimedia products for the Asian markets which include Japan, Korea, Taiwan, Singapore, Hong Kong and the People's Republic of China. This project takes the form of a series of five modules, each concentrating on a particular aspect of multimedia development and/or design. An overview of these research modules and their goals are as follows:

**Computer-Based Training Decision Aids Module (CBTDA):** In order for developers to effectively determine project requirements developing for Computer-Based Training technologies (e.g. project scope, key goals, targeted users, cost requirements like basic investments costs and return on investment or manpower requirements like needs for design, development, testing staff, or time requirements) tools must be researched and developed. This module will produce Chinese tools for projecting requirements for educational multimedia products, cost requirements for educational multimedia products, and manpower requirements for educational multimedia products.

**Tools for User Interface Design Module (TUID):** This module examines current products. It attempts to catalogue the most effective design strategies for Asian users and then produce guidelines and templates so that these strategies can be more quickly implemented in the development of locally-made computer-based products. Through it we also hope to produce tools to effectively combine elements of sound, visual images, colors, and text to develop easy to understand user interfaces for Asian students, and a catalogue of the most effective user interface design strategies currently in use.

**Display Style Technologies Module (DST):** This Module studies existing multimedia products and investigates existing design techniques from other disciplines (including: industrial design, clinical psychology, and graphic design), in order to develop guidelines, templates, and tools for use by Asian students, faculty, and companies to design applications. It will eventually produce guidelines which define the subtle uses of color coordination in interface design and the effective use of image symmetry and display balancing to produce more effective interface designs. We will also publish Chinese articles which describe design techniques currently used in existing multimedia products and currently applied in other disciplines.

**Interactive Technologies Survey Module (ITS):** As new technologies are introduced that allow users greater and more elaborate interaction with the computer, Asian developer's will require a greater knowledge of effective uses for these technologies as they apply to the Asian context. Ultimately this module will produce tools and guidelines which help developer's determine when to use specific interfaces, apply VR technologies effectively, and use these technologies to design products which can be adjusted to the needs of people with physical defects or special needs. In addition, we will publish Chinese articles which describe the subtle differences between various VR technologies.
Effective User Control Module (EUC): In developing multimedia applications it is not unusual for programmers to place too much control of the application in the hands of the computer. Users like to have control over the directions they take. In order to allow users this amount of control over their applications, effective user controls must be built into software packages based on Asian logic. This module's goal is to produce tools and guidelines which help developers produce multimedia applications for Asians which maximize user interaction and control and publish Chinese articles which discuss methodologies for maximizing user control of multimedia.
A Multimedia Computer-Based Test Generation System

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Introduction

In recent years, the importance of computer-based training has been widely recognized in both academics and industries. The success of computer-based training systems is partly attributable to their ability to evaluate the level of mastery the student has attained from instructions, i.e., the degree to which the student performance are congruent with the instructional objectives. In this paper, we describe a computer-based test generation system developed by the Computer Science Department at Utah State University. It was implemented using Multimedia ToolBook and Paradox in a Windows environment, and runs on either a stand-alone PC-based system or a networked system.

The Test Generation System

Our test generation system consists of five major components: Test Authoring Tool, Test Managing Tool, Test Taking Tool, Student Database, and Test Databases. Our test generation system can manage a set of related tests simultaneously. Each test has a separate test question database. Questions in a test are grouped into sections. Questions in a test for a given student are chosen from the corresponding test question database on a random basis. Questions may be labeled as required. Required questions are always selected. Currently, our system allows six types of questions, matching, sequencing, True/False, Multiple choice, Fill-in-the-Blank questions, and Graphic. The student database contains information about individual students. In particular, this database lists all tests that each student is required to pass and test results for all students. Each test result includes the number of attempts on a test, scores of attempts, dates of attempts, status (pass/fail/incomplete), and the result for every question on every attempt (correct/incorrect/unanswered). The test taking tool is for a student to take a test and list all information related to this student. The test authoring tool allows the author to create, edit, and delete test databases. When a new test is created, the author is first asked to input information related to the test, e.g., passing percentage. After a test is created, the author is able to create, modify, and delete questions. The functionality provided by the test managing tool can be divided into the following function categories: Management, Student, and Utilities. The management function category allows a test manager to perform certain management functions on the system. The student function category allows the test manager to perform student oriented functions. The utility function category allows a test manager to perform various utility operations.

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Creating Engaging Courseware Using System Dynamics

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A well-established principle for the design of learning environments is that learner-engagement is the key to learning effectiveness [see Gagné 1985]. Learner engagement, however, remains problematic because it is the learner’s cognitive engagement with the learning environment and associated learning materials that is the critical factor, and cognitive engagement is not easily detected or measured [see Spector 1994]. One method of achieving a generally high level of cognitive engagement has been through the use of system dynamics based learning environments [see Davidsen 1994].

System dynamics based learning environments typically consist of these elements: an introductory tutorial; an overview of a dynamic and interactive model of a complex phenomenon; learner access to model variables; opportunities for learner manipulation of model components; requests for learner interpretation of simulation runs; and opportunities for learner construction of alternative models. Feedback and discussion are integrated throughout the learning experience. Cognitive engagement is achieved by establishing a clear context for learning, by facilitating learner control, and by introducing unexpected outcomes in need of explanation and exploration. Such environments begin with an enabling phase explicitly supported by the introductory tutorial. Next is a processing phase in which learners become increasingly involved with the underlying model and its manipulation. The learning experience concludes with a resolving phase, consisting of group discussions of various experiences interacting with the model.

Evidence indicates that effective simulation-based learning environments can be constructed with instructional strategies built into the simulation engine so that as simulations are created they have inherent instructional value [see Towne 1995]. System dynamics based learning environments can be regarded as an extension of this technique, and they have the additional advantage of allowing a wide variety of individually responsive learner interactions to be designed and facilitated.

References


The University of Colima Distance Education System

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In the last fifteen years, and particularly since mid-eighties, the University of Colima has achieved a large advancement in its technological development programs. So, this institution automated the organization and systematization of the university libraries; it began the CD-ROM edition, aspect in which the University of Colima (UC) is the first one in Latin America that carries out this work and, in 1995, it inaugurated the first electronic library, unique in its type in the undercontinent.

To this processes the UC has added the incorporation of the inner communication network, the e-mail and the utilization of satellites, the introduction of optic fibre in the university campus, and the generalized access to internet.

In this sense, the computer mediated communication has reached the University of Colima work, it has propitiated the linkage of its researchers with colleagues from other institutions and countries, and this interaction is yielding now promising outcomes.

Nevertheless, this advancement on information and communication technology has not had an important influence on the undergraduate and graduate university programs. Some of this programs still remain with some traditional characteristics in their teaching-learning processes.

With regard to this situation, the institution has undertaken the University of Colima Distance Education System (SEDUC) whose purpose is to incorporate the methods, procedures, means and technical support of distance education to the current university programs, and specially to the graduate studies.

In this way, the objectives of the project point to prepare and to develop some proposals to improve teaching through the utilization of means and didactic strategies designed since different perspectives.

At the present time the University of Colima Distance Education Project is in the stage of design, where it tries to develop the following aspects: 1.- The organizative structure; 2.- Technology; 3.- The infrastructure; 4.- The pedagogical question, and 5.- Budget. The costs of design and the start of SEDUC are analyzed here (personnel, teacher and students training, equipment and its maintenance, production and delivery of teaching material), and the search of alternative financing sources.

In summary, the outcomes of this design stage should yield and clarify: the scope and prospects of the project, according to the availability of resources and means in the institution; the patterns and theoretical approaches for curricular development based on student’s requests; to link the different institutional departments involved on distance education; to undertake with all of them joint research projects on distance education and, finally, the results of these efforts must conclude with a outstanding proposal to improve the quality of academic work in the University of Colima.
Abstract: This paper presents research works concerning the way by which own knowledge can be built up. We show that the personal and mental work can be done more easily because objective information is embedded in subjective information given by multimedia features of the objects. It is possible to find out four laws about the exchanges between multimedia features in natural world and the knowledging processing. These laws give a basic model to design Computer Mediated Communication.

Introduction

In the domain of Computer Mediated Communication, one of the most important problems is psychological «distance» between the two actors of the communications, and this is particularly true in telelearning. It looks as if something important was not yet given in computer systems communications. The nature of this "distance" is unknown but it is not so deep that one can observe it, since multimedia is used on computer systems.

For example, telelearning is getting wildly used since teaching topics are least presented with text, digits and graphics. Multimedia makes the information richer. It can be seen that understanding is easy when the objects are presented as they are in the natural world. At this point, this description could perfectly show the advantages of any video presentation.

Multimedia used on computer systems as brought up for many years. More even it allows the user to personally interact in the artificial microworld. This is especially true in computer games commercialized by NINTENDO or SEGA. Some of the most evident characteristics are that these games bring pleasure and develop what can be named mechanics behaviors. However, this is not yet enough as a teaching tool. As it is known to us, game activity is very helpful to learn.

The game activity is well known to help learning but most of researchers admit that knowledging asks for a mental and personal activity [1].

The aim of this paper is to present the results of the research work upon the kind of information brought by multimedia objets. These information are perceived and understood immediately before any objective information given by the languages.

This paper concerns the domain of the artificial multimedia information management.

Those works as been used to realize a computer system designed for the reeducation of the capability to learn for deeply brain traumatized persons. The prototype of this system, including both a multimedia simulation module and a connectionist analysis module [2], has been experimented by about 50 illness persons and pre-validate in a medical environment on 20 patients. We present here the most important elements which hare the base of the simulation module.

At first, we shall present a specific definition of initial steps of Knowldging.

Secondly, four laws concerning the specific relationship between natural world and knowledging will be presented.
At last we shall conclude with a short presentation of some major applications of those works.

Zooming on Initial Steps of Knowledging.

Learning is a very high mental process; and at the same time learning always began in much modest activities such as smelling, seeing, hearing before memorizing [3]. This is the first step of knowledging about which we will talk.

Knowledging initial steps can be seen as a set of dynamics processes. They proceed to transform a simple perception of many distinct objects into one single abstract scheme. Each built scheme has a specific meaning and often corresponds to a concrete and useful behavior. A name will be given to this scheme (i.e. an abstraction) for communicating with other persons.

Let us notice that the manufactured objects have multimedia characteristics as natural objects. We still know that about sixty years ago, the major effort given to design manufactured objects turned to functional features; for example the first T-cars made by Ford were black with no other choice. After a few years, non directly functional characteristics had been given, but it was evident that the choices of objects bought were greatly influenced by subjective features. Even in the high level decisions domain, it is more often admitted that the decisions are not made by a research of the Optimal Rationality but by comparing the actual problem to past experiences: this attitude is inevitably subjective [4].

At this point, what we call knowledge includes two aspects: objective and subjective. It is named the "Total Knowledge" [5].

Now, we may say that the multimedia features in natural world present information concerning both subjective and objective domain. The latter is directly focused on the use of the objects. Later in this paper, we shall talk about "free information" which allows to build new knowledges deeply.

Though the basic nature of human knowledge remain a mystery, the nature of « the acquisition of knowledge » began to be described with the similar concepts in very different domains of Sciences:

Learning can be considered as a successful process to pull out one single scheme from different elements perceived in a close situation, in a useful project, and to directly reuse this scheme in others lightly different situations.

We have shown in our thesis report [6] that such a definition can be found in the works of Biologists, Neuropsychologists, Semioticians, Computer Scientists in Artificial Intelligence and Connectionist Approach specialists. [7 ; 8 ; 9 ; 10 ; 11 ; 12 ; 13].

Knowledging need energy at first

Some one is too tired to learn anything. And the focused aim of knowledging is regarded as a means to manage energy: it is more efficient to use one single concept than to use many and the process of making an abstraction has been named "Compress knowledge" [14] and « Economical Knowledge » [15].

It seems that God has grants pleasure to all that is important for human kind; for example young children try to discover and try to learn just as in a game. Moreover, it has been proved that pleasure makes associations areas more efficient in the cortex [16 ; 17].

We may say that some multimedia features of the word bring with a lot of emotional factors that facilitate knowledging.

Knowledging needs secondly to really perceive elements to be associate.

But people usually have a poor perception.
In artificial multimedia it will be possible to easily reinforce some specific features to make the knowledge richer.

Knowledging needs thirdly to reactivate old knowledges.

This does not need much energy [18] if the emotional and sensorial capabilities are made positive; it can be done without thinking over. Reusing an already learned pattern is well known in artificial connectionist computer systems.

Let us notice that knowledging is a personal mental process and that it cannot be seen. Fortunately, a knowledge is often directly linked to some specific behaviors that can be observed. Explanation by using language is a particular kind of behavior.

Here is an example:

When a mathematician reads written digits, he can immediately know whether the digits are elements of an single equation; after a quick glimpse, he can find out the most important elements of the equation; he can anticipate its resolution and can imagine, at the same time what can be done with it.

Knowledging needs to build new knowledge. This last step is the more difficult one.

The problem is to give a meaning to a set of particular elements needed to be associated. This is really a personal, difficult and mental work. Everything goes as if a person was trying to compare the elements at the lower level and to found the possibility to give them a global useful meaning.

This step can be automatically done if some similar situations where elements are shown are associated with interesting comportment well identify.

In multimedia simulations a lot of situations present a problem to be solved; it has to be chosen in the objective domain concerned by the communication. There, the aim of doing so is to help the person to learn the best method for solving the problem. The hypothesis is that when we teach the best methods in concrete problems, we help the person’s mental work; and we help her to build her personal knowledge.

At this last step, knowledging is very often processed in a social environment.

And so the person can use this wonderful tool that the men have created which is language. “Personal knowledge” is very often mixed with “Social knowledge”.

Let us resume: Learning is a personal mental construction using energy, based on concrete perceiving and allowing concrete behaviors to be realized with economic of means. The multimedia simulation will propose to teach the good behaviors in virtual microwords close to real situations. In this way, the details will be presented especially well and the context will be made richer emotionally.

Laws concerning the specific relations between features of objects and knowledging

The four laws presented here are one result of both our multidisciplinary research works and observations of persons’ behaviors whose brain have been traumatized; the first prototype of our MEMX multimedia simulation system have been used to observe the behaviors and to verify hypothesis.

We now generalize these laws into every situation of knowledging.

They define four following concepts:

Law 1: "Every object of the word must be considered giving three kinds of information which are:
- affective or emotional,
- useful features relative with already known objects,
- free information potentially relative to original or new knowledge."

Law 2: The "Objet Pivot de Connaissance" (Pivot Object of Knowledging)

Law 3 or "Transitivity law": it is said that a strong subjective aspect supported by one object is transmitted throughout this object. This subjective aspect is then supported by the context.

Law 4: "The specific meaning of information given by the objects is limited to specific socio-cultural populations".

Law 1: "Every object of the word must be considered giving three types of information."

2.1.1. The affective or emotional aspect of the objects

The word "object" must be understood in a broad meaning; it includes life situation; for example what we first look at is always to feel comfortable emotionally. If we are "freeze" emotionally, we couldn't see, nor hear, nor understand any thing. The answer is given by the existing of some very concrete signs or objects in the environment. Their only functionality is to give us an information in this domain of "emotional knowledge".

For example: Each of us has the personal experience of influence of the environment on the efficient of working. Temperature, music, colors of walls, the presence of an animal or of loved person do help or do inhibit mental faculties.

Then, every object (pencil, car, even writing notes) has qualitative feature whose functionality is to help us to manage our emotional needs.

The useful features relative to already known objects

It is considered that each of us may remember a situation in which he has not understood a very new technology because, in a first glimpse, he just wanted to observe the already familiar characteristics of what was presented to him. He looks a blind man on new elements.

It has been said before that the reactivation of old knowledge is usually automatic and that new knowledge is built upon a mixture of old ones.

So these kinds of features relative to old knowledge are useful and can be classified according to subjective information borne by the objects.

2.1.3. The free information potentially relative to original or new knowledge

Some of very creative persons are able to identify, by game, some new possibility to manage object because they can immediately found out specific features unused in traditional context with which something new can be done. But people very often have to be helped to find out the good behaviors by using the new objective characteristics of the objects presented to them.

2.2. Law 2 "The "Objet Pivot de Connaissance" (Pivot Object of Knowledging)"

It has been said that knowledging begin with the perceiving of a set of elements at the lower level of abstraction. This is not quite true because it has been observed that sometimes, one element (or a few number of elements) immediately drive the mind to a knowledge which might be true or false.

This element works just like a catalyst of knowledge. We name it as "Objet Pivot de Connaissance (OPC)" or "Pivot Object of Knowledging (POK)" in English.

Here is a few of examples:
- one kind of very specific yellow makes us immediately think of lemon
- in the scenario of a movie a specific music rhythmic immediately drives the spectator to a specific country
- a specific kind of smile lets a children immediately know whether his parents are pleased or not.

On the analysis phase of designing an application of Computer Mediated Communications it is necessary to find out these POK at the aim of rising them in artificial microword simulations.
2.3. Law 3 or "Transitivity law": "A strong subjective aspect supported by one object is transmitted throughout to the whole context of this object"

The meaning of this law is to manage the emotional environment. It is said that if one object particularly rich in emotional information is placed in the context of life, all the context will be richer.

For example, in the first prototype of the system MEMX, I planned to make persons work in a virtual kitchen: all cupboards can be opened and closed very easily, and it was possible to move pans or plates from the table to the cupboards. But something was wrong that I did not understand until a lady said: "Your kitchen freezes me!". I then draw a bouquet of nice flowers and very colored curtains on the windows. Everything got in order. Moreover, it was possible to observe that the flowers was the first object that all patients first looked at.

2.4. Law 4: "The specific meaning of information given by the objects is limited to specific socio-cultural populations".

For example, some brands of cars always give their owner a kind of social prestige... a sweet pink Mercedes will not bring the same "image" to its owner in Boston as in Hong Kong.

This law takes into account the knowledge background and the difficulties that different populations have to meet when they have to communicate; for instance, trying to transfer the use of new technologies from one country to another.

We have already known that the same words (even translated) do not have the same meaning for different populations; advertising profession knows it and uses it to choose to communicate by convenient images. A similar proceeding has to be done by using artificial multimedia on computer systems. Multimedia is a marvelous tool to assist communication between people that have different knowledge background [19].

Conclusion

In the works presented here, both theoretical and applied, two type of problems have been crossed over:
- The first one concerns the managing of subjective information in computer systems.
  We worked by using original methodology, specific formalism and tools that have been designed [19].
- The second one is the problem of the validity of the tool.
  First of all, the good acceptability of the system by the users is the basic condition and it must be evaluated before any validation of the system efficiency

Then the problem of the validation of the system efficiency has been resolved not by asking the users but by proposing them more and more difficult different problems to be solved. We have measured their autonomy and their ability to solve the same kind of problems in the real life with out using computer systems.

Those works concern a lot of applications.
The first family of applications concerns computer science domain:

1. It opens a way of designing knowledge Database of "Total knowledge"; for example specific POK and couples of subjective information relative to specific multimedia features in different socio-cultural populations.
2. On analyzing the user's behaviors within different multimedia simulations (built as we said), and by using Kohonen maps [11], it is possible to find out different types of mental behaviors which was not possibly found before[6], nor by classical tools.
3. These simulations coupled with connectionist systems of analysis constitute an original Hybrid Tool for Knowledge. It can be used in Decision Emerging System [2].

Another family of applications is directly operational:

4. These results help to get the assistance of learning more efficient when people do not have a good self management of language or when they do not have the same knowledge background. As it has been said, this is the case when transferring the use of new technologies from one country to another. [19].

5. At least, these works are particularly taken into account in Distance Telelearning to make up for the need of human « presence ». 

We are now working on the "PROJET TELEACCOMPAGNEMENT". It concerns illness teenagers obliged to stay home for long months. This project will allow teachers to communicate with the youths by multimedia applications on the net. Our works will be taken into account.[20]

On presenting these works, we hope to contribute to Scientific Community Research works, focused on the riches of multimedia information.

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A Model of Architecture for Integrated Open and Collaborative Hypermedia

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Introduction

Integrated Open Hypermedia (IOH) systems bring together various kinds of information (Hypermedia) that can be linked without restrictions (Integrated) and can interact with other systems by means of information interchange (Open) [Goldfarb, 1991]. The hypermedia philosophy of maximum collaboration has recently gained importance, so that IOH acronym has to be expanded into IOCH, where C explicitly represents a system support for collaborative work that goes beyond system openness. In a technology like hypermedia, where there is hardly any theory and developments follow no standard methodology, a model of architecture, in which IOCH system problems are considered, could be an important aid for beginning system design. The problems associated with IOCH systems, as in other software development, can be solved at any development cycle phase, but as software engineers have insistently repeated, the sooner detected the simpler and cheaper the solution. In addition a model of architecture can facilitate the definition of the software system structure, by specifying its basic modules and their relationships.

A model of IOCH architecture

The model of hypermedia architecture here presented is based on four principles: Modularity, so that a system is composed of several layers; Abstraction, which ensures that each layer has a different system view and only focuses on certain aspects; Collaborative Authoring which involves issues such as information sharing, personalisation and security; and Distribution, since any part of the hyperdocument should be used in any platform (see [Shackelford et al. 1993] or [Gaviotis and Christodoulakis 1995]).

Considering these principles, the model divides a system into four layers: Delivery, Application, Conceptual and Physical. At the Physical Layer, hyperdocument is considered as an information mass devoid of a special meaning or structure, using two elements: the Information Base, which holds the physical data, including structural, presentation, delivery and usage information; and the Hyperbase Manager, which is responsible for the interaction with the Information Base, tackling problems such as transaction management, security, information locking and distribution. Conceptual Layer gathers the way this information mass is conceptually organised through three components: the Conceptual Scheme, which represents the static hyperdocument structure using the elements of a hypermedia model; the Operational Module, which performs dynamic operations on these conceptual elements; and the Inference Module that deduces other operations that should be performed as a direct consequence of a system status and a previous user's behaviour. Application layer builds a virtual hyperdocument independent on hardware and software restrictions. Its definition requires four modules: three of them represent the categories of operations that can be performed (Authoring, Navigation and Search Modules); and the fourth, the Communication Module, favours users' collaboration. Delivery Layer has the same hyperdocument view as the user. This layer adapts the virtual hyperdocument using two modules: the Operating Environment that presents information to the user respecting the physical restrictions; and the Adaptation Module that converts the virtual hyperdocument into the format of the tool being used.

The implementation of a model of IOCH architecture will result in a generic platform that would do away with a series of rigid ad hoc architectures that make systems closed and unable to exchange information.

References
ICAS was planned and developed as an interactive computerised assessment system in order to provide an alternative learning experience for students and to achieve a more efficient use of teaching time. It was not designed to replace bedside specialised subject area teaching. Instead, it supplements paper-based learning, but is more fun than a book, and appears much better visually. It can be described as a learner support environment, because it assumes that the intelligence resides largely with the student and thus it concentrates on providing optimal conditions for learning. It makes use of interactive CAL, by promoting active learning in which there are high degrees of participation and involvement by the student.

The objectives behind the planning and subsequent development of ICAS are as follows: to aid management of learning, testing, tutoring, exercising, dissemination and archival of material. ICAS Modules have been developed in problem solving, drill and practice, and tutorial modes. One of the important functions of ICAS mentioned previously is that in which the computer is involved in the management of the learning process. Because of its record-keeping ability (and analytical power), ICAS can monitor a student’s progress through the course of the instructional material.

The ICAS system consists of four inter-linked components:

- The core ICAS system.
- Modules, each containing a database of specialised questions with answers and explanations.
- An on-line tutorial for beginners to the system.
- The fully context-sensitive (to specific subject areas) multimedia hypertext help system which contains high quality images, and links to the questions in the associated database module. This is a useful and interesting way to revise the material quickly.

The basic philosophy underlying ICAS’s multimedia approach to instruction is that a number of different media are used (simultaneously or in sequence) in order to implement a learning task. The full ICAS system utilises the latest multimedia technology by integrating text, photographic quality colour still images which greatly enhances the capabilities of the hypermedia tutorial and on-line help, in addition to planned use of video, sound and animation.

The teaching methods and media used in the development of ICAS were chosen to catch the learners' interest, to remind them of earlier learning, to stimulate new learning, to explain subject-matter and provoke thought, to get learners to respond actively, to give them speedy feedback to their responses, to encourage them to practise and review, and to help learners to assess their own progress. There are many hours worth of potential study time available; therefore the ability is always present either to revise topics or test individual knowledge. ICAS has been designed to be of use again and again. In its entirety, ICAS is a shell system with a number of modules of specialised knowledge to accompany it, with hundreds of questions available in the system. To date, modules have been developed in General Surgery, Opthamology, Dentistry and Information Technology.
Properties of Text

Text defined as semantic unit and cohesion as those linguistic properties enabling text to hang together linking both prior and following elements [Halliday and Hasan 1976] applies to concepts of traditional linear text and non-linear (hyper) texts. Lexical cohesion in literary analysis highlights how "chunks" of text can cohere sentences or pages apart. A decomposition of these chunks illustrates how inter-textual and intra-textual observations forge relational ties that anticipate the links in hyperdocuments.

Chunks and Nodes

The following semantic units or chunks from a student text illustrate non-linear placement in traditional text, where the student comments on Biblical/Mythological events. While the chunks cohere at a distance of 19-20 sentences, they also constitute embedded links: women/Esther/Athena. The hierarchical placement of semantic units anticipate associative hypertext networks and their nodes.

S.4 Women with positive traits are depicted beneficial and helpful to men.
S.23 Esther used her beauty and charm to persuade the king not to harm her uncle.
S.24 Athena helped Odysseus to arrive safely home to Ithaca.
S.30 Women are sometimes shown as sexually immoral or ignorant.
S.36 In Of Mice and Men, Steinbeck characterizes his female characters as harlots.

Network Properties

While these semantic chunks reflect narrative typologies of events, characters, place, etc. their composition in scientific or technical disourse may illustrate further perspectives as documentation procedures and examples. Similarly, a principle of nuclear physics may be followed by a Quicktime Movie or animation. Just as traditional text has been systematically analyzed for "excellence" based on its distribution of cohesive agents, hypertexts should be analyzed for network configurations by author objectives.

Key questions require answers: (a) How does the internal composition of a node facilitate recall? (b) What are the cohesive implications for sound and visual representations in the language mix?

References


Fixing Chinglish!: Educational Multimedia for Asian ESL Training

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Although the average Taiwanese student will be exposed to a minimum of 6 full years of English training, less than 20% of them will retain enough to carry on even the most rudimentary conversation or read even the simplest magazine articles. This hardly seems surprising. First, language in countries like Taiwan is learned "in isolation. When class is over, students walk out of the classroom and all language learning stops. In addition, large class size makes even those hours spent inside the classroom less valuable. Teaching is done on a rushed schedule that seldom meets an individual's learning needs and the rote memorization and drilling which many teachers must resort to make drown out most student enthusiasm.

Meanwhile, parents and educators find themselves wading through mountains of new multimedia software promising to solve these problems. Unfortunately, after weeks or even months of investigation few of them find educational software which can meet their needs. What they find, as often as not, is software with few clear educational goals and a vague understanding of how to use that software effectively. Many of them lack the educational architectures [Schank, 1990] necessary to initiate the learning process (opting instead for games loosely cloaked as educational materials). Others fail to provide goal-based learning [Schank, Fano, Jona & Bell, 1993] or other strategies that will hold the student's attention. Most importantly, almost none offer interfaces, metaphors or mental maps which Asian students can relate to. It is a frustrating situation created because developers don't know what students need and potential customers can't define what they want.

The solution we are currently examining is named "Project 'E'. The Project covers grades K to 12 as well as college level English. Its basic methodology is an extension on the methods currently in use in the Title 7 CELL Program currently under study in the Irvine School District. Like a doctor analyzing a patient's symptoms, students are tested for specific skills on a per-semester basis. The results of those tests are then subjected to what we can "Prescriptive Analysis." The goal of this analysis is to prescribe a battery of multimedia software programs which each student can then use to eliminate their particular skill deficiencies. Students get a few hours at school per week to work on these programs. Moreover, parents are advised to "push" use of these programs at home as well. The result is greater "one on one" exposure to English on problems the student clearly needs work on.

In addition, creation of the lists used in the Prescriptive Analysis point out where specific types of software are lacking. These "holes" in the available technology constitute potential market niches for software designers. The structure of Project 'E' makes it possible to outline and quantify the pedagogical requirements for those niches.

'Fixing Chinglish' is a prototype software package designed to fill a niche in the Project 'E' model. The user of 'Fixing Chinglish' is a first year college student placed in an incidental learning architecture where he or she plays a spy assigned to enter the United States. Assisted by a number of 'Trainers' who provide basic training sessions, case-based lessons on cultural issues, and supplementary language information (on an optional basis for the interested user) the 'Agent' attempts to enter and begin 'operations' within the US. Each module introduces new opportunities for the user to further entrench him or herself in US culture and each module cascades previous problems in order to insure that, once learned, neither linguistic nor cultural items are wasted or forgotten.
'Fixing Chinglish' is composed of two separate units, the Prescriptive Analysis prerequisites demanded by the Project 'E' format and the Entertainment format. These individual units can be logically separated in order to create alternative software for users who might not find something like a spy scenario interesting or to carry the scenario on for those students in second or third year university courses who might wish to continue their role playing as they continue to strengthen their individual language skills.
The Authoring Dilemma

Most teaching staff can use a word processing package and, perhaps, a drawing package, but would stall at the challenge of progressing to more complex software packages. The multimedia/hypermedia authoring process consists of a set of phases, each posing particular problems; learning/mastering the software; expression of a knowledge domain into a suitable structural format for ‘computerisation’; identification and development of appropriate resources for inclusion in the final product; and finally transposition of resource materials into a hypermedia. Often these phases take place simultaneously increasing the already high cognitive overhead. This paper proposes the use concept mapping tools as way to mitigate against such cognitive overhead.

Concept Mapping in Reducing Cognitive Overhead

There is a considerable similarity between concept maps (as a means of knowledge representation) and hypermedia structures (for knowledge emulation). The similarity is even closer for hypermedia designed to deliberately reflect the underlying structural knowledge of a domain, i.e. semantic hypermedia. Both techniques represent knowledge domains diagrammatically using graph structures that involve a set of nodes connected by means of labelled and directed arcs. This similarity can be exploited in the hypermedia authoring process.

Authoring Educationally Effective Hypermedia

Hypermedia applications designed for education must be effective in enhancing the learning process, otherwise they become nothing more than sophisticated information bases. By mapping the functionality of computer-based concept mapping tools to educationally effective hypermedia the requisite functionality of concept mapping tools for hypermedia development can be identified. This mapping has resulted in SHAPE, a prototype concept mapping tool interface to the de facto hypermedia authoring standard Asymetrix Toolbook.

SHAPE : Semantic Hypermedia Authoring Package for Higher Education

SHAPE is designed to facilitate semantic hypermedia authoring whilst reducing the cognitive overhead of expressing a knowledge domain. SHAPE, therefore, allows a developer to explore the knowledge domain of interest, and then, through suitable ‘post-processing’, compile the resultant model into a skeletal hypermedia knowledge corpus. There are other authoring programs that take a graphical approach to authoring, however these focus on flow diagramming and tend to prescribe the order in which the material is viewed and activated.
Embedding the Aesthetic Objective in Educational Multimedia Design: Adding the Human Element

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Aesthetics are extremely hard to define, difficult to implement and almost impossible to evaluate. Do we really need to consider aesthetics? Yes! Aesthetics are a part of everyday life. It would be naive to live under the impression that learners are not affected by emotional needs, resistances, and preferences. When in fact, every instructional presentation is first perceived subjectively by its audience. Therefore, this research will address the probable considerations, and the integration of aesthetics as an essential design feature used to enhance a student's learning.

Aesthetics is an area of study that is concerned with feelings and sensory experiences. It also refers to the skills needed by learners for the ability to judge whether or not an art form has belletristic (beautiful, masterful, containing class or good form) value. Aesthetic education includes all areas of art, such as visual art, music, dance, and theatrics.

Indirectly exposing learners to aesthetics is rarely considered in educational multimedia design. Educational multimedia designers should not actually teach aesthetics, but rather provide an aesthetic experience through the design of an aesthetically sound educational program. This can be incorporated by carefully establishing additional aesthetic awareness objectives within a properly designed program. The two ways to facilitate an awareness are; 1.) using resources that have aesthetic value, and 2.) intentionally embedding aesthetic objectives within the main purpose of a multimedia program. These two areas are reliant upon each other and are inseparable in all aesthetically sound programs.

The purpose behind aesthetic development is as important to the success of a program as the content when incorporated correctly. If a designer carefully selects aesthetic material and integrates it appropriately without distracting from the main purpose of the program, students can become more motivated and involved with the subject material. Belletristic art forms should be used to heighten the aesthetic characteristics within well designed multimedia programs. Four areas designers should consider are the 1.) development of a continuing art theme, 2.) use of quality visuals and sounds, 3.) relation of aesthetics and the content presentation, and 4.) promotion of concurrent emotional and cognitive responses of the learner.

The second way to establish an aesthetic experience is by implying subsidiary aesthetic objectives within a content presentation. Designers can increase aesthetic use, recognition, and awareness by integrating it within their instructional programs. This is also a consideration for educational media professors and instructors. Students will naturally model the examples given by their instructors; therefore, instructors should consider aesthetics in their own presentations.

With the constant push for professional presentations, creative designing, and interactive operations, educational multimedia designers need to consider more than just content presentation. They need to get an edge on aesthetic awareness and be able to incorporate aesthetics for better learner attention, content relevancy, student assurance, and program satisfaction. The multimedia field requires strong aesthetically-minded designers who can balance between functional programming and extreme subjective programming. Often good programs are critiqued harshly because the designer did not consider aesthetics worthwhile. Indeed aesthetics are important, and with multimedia, learners can be taught as well as motivated by aesthetic awareness.
Many teachers contend that art cannot be taught. Others appreciate the need to teach aspects of art but are unsure of exactly what or how they should teach. Persuading teachers that there is a body of art knowledge which non-specialist teachers can successfully impart to inform pupils and thereby lay the foundation for the development of their artistic talents is a major in-service task.

Basic principles can be taught most effectively within the area of "visual education" which comprises a language composed of visual elements, the formal organisation of these elements and the process of analytical observation. The language element is critical. Art is a language, a key form of communication which has a characteristic, fundamental, visual vocabulary which requires a parallel verbal explanation as the words used have specific meaning. Without knowledge of these visual and verbal concepts and terminology of art language, teachers cannot begin to understand how they should progress a child's development in visual education. Once they have acquired this vocabulary teachers should also understand what they should teach and how they might react to and discuss, in an increasingly meaningful and sophisticated way, works of art and, indeed, work in art.

To date in-service teacher training of non-art specialists has been effected through tutor-led, college-based short courses. Such courses have transformed visual education in many Scottish schools but are time consuming and impact upon only a fragment of the teaching force. To attempt to service the entire teacher market would inhibit development and delivery of more advanced courses dealing with deeper understanding of many aspects of art.

Enter a technological solution. We concluded that a major part of basic art education courses which introduced teachers to visual education could be effectively delivered through school-based, CD-ROM oriented, staff development. Our first CD "The Language of Art" deals with observation of how the seven visual elements (line, shape, dimension, pattern, texture, tone and colour) are used in art works. The relationship of shape, dimension, pattern, texture and tone to line is clearly illustrated and the user is advised on routes of study.

The CD-ROM holds over 150 high-quality colour reproductions of drawings, paintings, collages, prints and friezes (originally created by pupils in primary schools), allows access to individual slides, sequences, animations and video snippets and provides detailed textual explanations of all of the illustrations, key words and concepts. It includes every piece of art work used in traditionally delivered courses. The animations and video snippets are the easiest way of explaining certain elements of form, texture and pattern and the most effective way of establishing perceptual understanding. The determination, structuring and interlinking of the content reflects rigorous appraisal of course materials, art techniques and teaching strategies.

Teachers can use this resource in school, either on an individual basis or in small group mode - possibly spreading in-service school wide. Users should progress from looking and not seeing to looking and seeing in a highly focused and critical manner. This development from elementary introduction to perceptual differentiation will come through constant and increasingly detailed practice, observation and analysis. The users will then be equipped to apply knowledge of the visual elements to practical pieces of art work and gain deeper understanding of the expressive qualities of any piece. In addition, participants should progressively be able to view any image, formulate possible teaching objectives and create appropriate teaching and learning situations.

The project has helped to clarify and inform a major area of in-service activity. The resource should prove to be a significant contribution to art education and herald the development of a CD series dealing with specific aspects of art. Evaluation of the extent to which this resource improves teacher knowledge and understanding of the language of art and of the effectiveness of this innovative form of course delivery is now underway.
In the delivery of open learning and distance education courses, there is an increasing trend to provide study information to guide students in their learning process through an electronic form. Study information for students involved in off-campus study typically incorporates a subject study guide which includes essential information intended to provide a substitute for on-campus face-to-face teaching of the same subject. This electronic version may merely be a series of text-based screens which are a simple substitute for the traditional printed version sent to the student or it may capitalise on the potential capacities of electronic presentation by providing increased learner control in the learning process through the design of alternative navigation options for individual students. In addition, there is also the alternative of providing interactive multimedia programs as part of, or as the complete course delivered electronically to the student. Electronic delivery may be provided through delivery of the subject to the student’s computer via an electronic network or in the form of a set of floppy disks or a CD-ROM disk sent to the student.

To the student, this electronic delivery of essential course and subject information represents a significant change in the way information is presented and the way in which the student will interact with the study materials. At Monash University, the evaluation of the traditional print-based learning materials for students involved in study off-campus has been provided by the Distance Education Centre as part of the instructional design process. Feedback from these evaluations has proved very useful in the revision and redevelopment of these courses. Currently, additional criteria have been identified as part of the evaluation of subjects which are delivered to students in the electronic form. These criteria include previous experience in computer based learning, the impact of computer based subjects on the study environment, the specific characteristics of each electronically delivered subject and the student’s assessment of the further potential of providing subjects in this format. In addition, the affective impact of these materials is being evaluated.

This paper describes an instrument specifically developed for the evaluation of subjects delivered to off-campus students through electronic means. This instrument is based on the development and refinement of evaluation criteria through the ongoing evaluation of subjects offered through the Distance Education Centre at Monash University. A resource bank of survey questions, specifically designed for the evaluation of electronically delivered distance education courses, are incorporated into an existing computer software program, Subject Evaluation Software 1.0, developed and produced by Griffith University in Australia.
Developing Multimedia Courseware: Two EFL Applications for Teaching Phonetics

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The present paper demonstrates Transit and SoundSleuth, two applications developed as self-access modules in a phonetics course for preservice primary school teachers of English. Transit provides practice in phonemic transcription through drills - "offset" by the occasional game - covering some 750 words and phrases. Some items are presented in standard orthography, but most must be transcribed by listening alone. Students enter responses using a "point-and-shoot" IPA chart on the screen and have access to the pronunciation of all items, which have been recorded by native speakers of British English. The program provides diagnostic feedback for each attempt and saves errors to disk for review.

The pedagogical motives for self-access in the present case are familiar ones: students acquired transcription skills at very different paces in a classroom setting, and one teacher proved woefully inadequate for what is an intensive learning task. Using Transit, students now work at their own pace, with a tireless native speaker to repeat items with a click of the mouse. While transcription is a useful tool that enables students, with the help of a good dictionary, to anticipate and practice difficult items on their own, the ultimate goal of the course is obviously accurate pronunciation. Accuracy - at least at the segmental level in careful classroom speech - is very much a survival skill for my students, since their supervising teachers are quick to pick up on typical errors such as the confusion of the English sibilants, the lack of aspiration with the voiceless stops, and incorrect word stress. The crucial linguistic issue here is thus how - or whether - passive practice in discriminating English phonemes translates into improved productive skills. For present purposes, it is blithely assumed that such practice is a necessary condition for accurate production, and Transit dutifully attempts to bridge the reception-production gap by allowing students to record their pronunciation and compare it to the models. The value of such "interactivity" remains uncertain, however, without the ready availability of adequate speech recognition technology.

SoundSleuth is an adaptation of British Accents and Dialects by Arthur Hughes and Peter Trudgill. Working with recordings of key words and short anecdotes for ten dialect regions in the UK, students first carry out "virtual field work" and then attempt to identify fifteen test passages. The main screen contains a map indicating each region and a list box with the 52 key words. Using the graphic and the list together, students construct sets of items for contrastive analysis; for example, by listening to the set London_put, Newcastle_put, London_putt, and Newcastle_putt with successive clicks of the mouse, they observe the lack of a distinction between the vowels in the North. The map provides links to individual pages for each region containing the text of the recording and controls for playing it; within each text, hotwords provide notes on individual words, and bookmarks divide the recording into manageable units for intensive listening. The students’ first task is to summarize the recordings without the aid of the text, comprehension being a good first approximation to "deviation" from RP; they then proceed to make more detailed observations, guided by off-line materials towards prominent, yet sufficiently distinctive, features of the dialects. After a first round of note-taking, learners are encouraged to tackle the test passages.

British Accents and Dialects is an example of worthwhile book-and-cassette material crying out for computer delivery: it is pedagogically crucial for learners to be able to juxtapose key words, recordings and test passages - an impossibility with a linear cassette. In particular, the technology facilitates the successive comparison of recordings essential when homing in on a match among the dialects for a given test passage. While obviously designed to sharpen the ear, like Transit before it, SoundSleuth has the additional, broader aim of fostering an appreciation of diversity in language and, thereby, of tempering pedantic notions of "proper" English.

Both applications were programmed by the author using Toolbook 3.0 under Windows 3.1. The size of the sound files, some 150 MB in 16-bit format at 22 kHz, makes CD-ROM the only viable medium for delivering the
software.
Eleven Lessons from the DAGS'93 Hypermedia Conference Proceedings
(Short Paper)

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The Dartmouth Experimental Visualization Laboratory has developed a number of interactive conference proceedings that incorporate audio, video, and transparencies from conference presentations in addition to more traditional textual and prerecorded video components. In this paper, we summarize lessons from the construction of a feature-rich proceedings that provided sharable annotations and user-definable links and trails through both papers and presentations, but which was less successful in terms of economics and time-of-delivery. We expect that our experiences will help those creating other large, time-sensitive, and interactive hypermedia objects.

Lesson 1: An electronic publication has both an interface and content. Allow sufficient time to build the interface and incorporate the content.

Lesson 2: An electronic publication is more than content. Make sure your publication includes an appropriate collection of features that draw upon lessons from information retrieval, human factors, hypermedia, and print-based publishing.

Lesson 3: Obtain the complete specifications for your interface in advance, as late changes to the specifications often require significant redevelopment.

Lesson 4: You will eventually be called upon to port your interface to other systems, so do not overuse systemspecific features.

Lesson 5: An electronic publication is more than features. Make sure your publication includes valuable source materials, that the materials are of sufficient interest to justify the time and expense, and that your software platform can support the structure and format of your content (e.g., images, formulate, tables).

Lesson 6: A publication is limited by the recording quality of source media, which may be difficult or impossible to recreate. Spend the time, money, and effort to ensure that source media are of sufficient quality.

Lesson 7: Multiple document formats impede development. Choose an appropriately robust format, train your authors, and ensure that they use the format.

Lesson 8: Technology is changing quickly. Realize that consumers may want the latest technology, but the latest technology may not serve your needs.

Lesson 9: Keep a close watch on the project’s progress. Almost everything will take longer than you expect.

Lesson 10: Timeliness is next to godliness. In some cases, it is better to produce a simple document, than an extensive, fully-edited, multiply-annotated, well-featured system.

Lesson 11: Electronic publishing is still a new endeavor, and for many projects, the lessons learned and interface developed are as important as the actual publication.
A Different Learning Approach: The Hypertextual Paradigm

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This paper aims at showing that the hypertext production process, supported by the use of multimedia technology, is so similar to the learning process that the hypertextual paradigm may be transferred into the educational field. In the history of the human progress, paradigms preside over the knowledge development, causing, whenever they change, a real revolution. The definition of a paradigm inside a field of the human activity renders that field scientific. The training is a basic activity of the human progress. By finding out and defining a new paradigm it is possible to provide the preliminaries for developing an innovative kind of learning. Given an hypertextual structure formed by multiple informative sources supported by hypermedia and a series of links, the hypertext is an individual production of the user. He becomes the subject and the trained object of the hypertextual product.

This is the analogy which allows to transfer the hypertextual paradigm, if defined, into the educational area. So doing, the training process may be formalised and managed artificially - which means without the contribution of the teacher who normally co-operates with the learner in the training process. The hypertext mirrors efficaciously the mind of its builder, starting from the multimedia elements which represent the world faced by the learner both in an emotional context and through an active or planning interpretation. In this perspective it makes sense to introduce in the field of Educational Science the term and concept of system, overcoming the perplexity of some scholars about an action which may otherwise seem meaningless and even incongruous. In the field of systemic modelling there is a difference among the isomorphic formal analogy between the paradigm and the model, and the ommomorphic formal analogy between the object and the model itself. The knowing action of the observer towards the object is performed through the representation system and it is not neuter either for the object or the observer who is obliged to re-conceive his models according to the increasing knowledge of the object. The systemic modelling may be considered constructive because knowledge is not a final truth, but a construction: knowledge is the action of building knowledge. Modelling is conceiving, building, and learning how to use tools. The modelling tools belong to the representation system chosen by the observer in order to reach his goals. The tools of the hypertextual representation system are the hypermedia languages: words, sounds, images, objects. They are metaphorically organised according to a web of evocative links in order to build the hypertext. For isomorphic association with the representation system, the hypertextual paradigm may be defined a web of evocative links. The verb to evoke may be referred to the subjective organisation of memory and perception. Indeed, the analogy is a question of perception. The term web may be metaphorically referred to the paradigm considered as construction or artifact. It is an artifice for solving puzzles and a concrete way of seeing. Khun takes into account actual artifacts used analogously. Like an immediate analogy, a web of evocative links is limited in its extension, not directly comparable with another, and extensible according to an inferential process of reproduction. It fails if it is extended too much. The hypertextual paradigm is a training tool. It allows the construction of new models: indeed, each person becomes a designer when he shapes projects of change. Analysing the logic categories of the learning process, Bateson underlines that the word learning implies a sort of changing. The training, in fact, modifies the mental organisation and pursues the acquisition of new abilities and knowledge. Moreover, a change denotes a process, but processes may be changed as well. They can quicken, slacken or be submitted to modifications, and then defined as different processes. Really the media message consists in changing proportions, rhythm, and schemes of the learning processes which are based on the building of knowledge networks. Recent studies in the field of Cognitive Sciences are centred on the learning through authentic activities. The associative, non-linear, nature of hypermedia allows to increase these capabilities, developing meta-knowledge more than the traditional linear tools. The hypertextual paradigm
in training is a paradigm for the development and control of the dynamic aspects of a process which mirrors the process of the long-term memory structure, activating the higher-order thinking.
Reflections on the Multimedia Explanation

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Introduction

The aim of this paper is to focus on the Explanation process performed through multimedia tools. Firstly, we highlight the main benefits owned by the Multimedia in an explanation process; then, the most critical design issues, which might vanish these benefits and should therefore be avoided, are introduced.

Between the facets of the “Explanation” concept, we are particularly interested in stressing the communication one; to this end, we regard the “Explanation” as a communication process aimed to allow the comprehension of a knowledge domain; by communicating the Information domain corresponding to the knowledge domain. Consequently, searching effective explanation solutions includes the exploration of effective communication processes and tools.

In order to produce very effective benefits to the explanation process, some important operations can be applied to the Information which must be communicated (corresponding to the knowledge domain). Since these operations can be easily implemented in a multimedia environment, multimedia explanation have these benefits at their disposal.

The basic idea is: each information domain can be recursively decomposed - according to a top-down approach - by a resolution operation, into information modules. Sub-module comprehension turns out to be simpler than their parent module comprehension (in the reduction process). Eventually, the resolution operation will lead to information modules which do not require any further decomposition to be understood.

Information modules can be hierarchically or hypertextually connected, by an Integration operation, in order to reproduce the structure of the Knowledge domain.

The comprehension of a sub-domain of a knowledge fields requires the communication of a subset of the information modules of the original domain. The Reduction operation allows to get an information sub-domain from an original information domain. Note that this operation is not to be confused with the Resolution operation. By applying the latter to an information module, the amount of information owned by the original module is distributed between the sub-modules produced by the operation.

According to the previous considerations on the Information, we can report the most significant benefits of Multimedia in an explanation process.

Firstly, both resolution and reduction operations produce information modules with different explication needs. According to their needs, information modules can be classified into classes; each class can be coupled with one or more media (text, sounds, graphics, animations, etc) which particularly fit the communication needs for each class; multimedia allows to keep all the necessary media to communicate modules from different classes in the same explanation tool.

Secondly, the resolution and integration operations are fundamental to the hypertextual organisation of the information. By considering the comprehension process as the reconstruction in one’s own mind of the model corresponding to the knowledge domain, the possibility to preserve (inside the multimedia explanation) a model
which is structurally isomorphic to the knowledge domain makes the multimedia explanation extremely effective.

In addition, keeping in mind the explanation as a communication process, the multimedia explanation inherits all the communication benefits which have been already proved for the multimedia communication in general.

Finally, an additional advantage which is not stressed enough in literature regards the reduction of the reading time necessary to read a multimedia document. By using graphics, animations, sounds and all of the media available in a multimedia system, reading a multimedia documentation system requires much less time than reading the same information in a traditional form. As a consequence, training and educational courses which include multimedia staff can require much less time, efforts and costs than traditional courses.

Benefits of the multimedia explanation might be made fruitless by a bad explanation design. In fact, the multimedia explanation, compared with the traditional one, implies design issues which are extremely tricky in order to get a correct design for the multimedia explanation. We introduce three important design issues: perceptive interference, perceptive overhead and cognitive loss.

By presenting each of these issues, we also introduce some general design guidelines which might be used in order to overcome the design issue.

Perceptive interference problem arises because of the simultaneous not synchronised use of 2 or more media; it makes users perceive communication noise instead of correct information. The absence of synchronism can be real or potential. It is real when it does not depend on the user (e.g. not well-synchronised integration of animation and text); it is potential when it depends on some user's parameter: a speaker in a multimedia system reproduces exactly a piece of text which is also shown on the screen; if the user's natural reading speed is not the same as the system speaker's one, s/he will eventually decide to read by him/herself and ignore the speaker, or vice versa.

Perceptive Overhead problem arises when too much information (with respect to the information domain and to the time) is communicated by the explanation; as a consequence, the user can undergo some perceptive problems. To be more precise, users are not able to distinguish between the most and the least relevant information modules or they are not able to identify the chunks of information which are relevant at a specific time.

A similar problem is well-known in cognitive science, referred to as the cognitive overhead, and occurs when the user cannot comprehend all the information s/he receives, for example because it is received too quickly; however, in that case, the user can still perceive it. The notion we are introducing regards the perceptive aspects instead of the cognitive ones.

Finally, the Cognitive Loss problem obstructs users from understanding the links existing between the different information modules which constitute the information domain. This occurs when information modules are presented in a not integrated way by the explanation.

This case includes the well-known problem of the loss in the hyperspace. Actually, the user cannot understand the links between the module which is being explained and the network of concepts corresponding to the knowledge domain.

Specific design strategies should be taken in account in order to avoid the illustrated problems.

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Institutional Faculty Development in Education Technologies to Improve Classroom Teaching: Launching the IDO Pioneers and Guides

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There is a major challenge facing all university educators today. Students are more different than ever before. They have increasing cultural, educational and experiential differences. They are older; they work; they go to school part-time; they have trouble trying to fit into the mold created for them. Their expectations for a stimulating learning environment makes them less tolerant of, and less likely to sustain interest in, traditional classroom environments.

Along with the changing profile of today's students, there are new and strong competitors in the educational marketplace. Beyond substantial industrial and on-site education, there are the educationally-morphed cable entities, and, just on the horizon, poised to further blur entertainment and educational enterprises, are the interactive video and virtual classroom phenomena, which, coupled with the Internet, will soon allow anyone to claim to be a university.

Institutionally Focused, Technology Based, Faculty Development: The Instructional Development Office. In order to contribute to and compete in this new environment, university faculty development efforts have turned to technology, which offers innovative techniques to enhance and enrich learning. To support this realignment of teaching strategies, George Mason University (GMU) established in 1991 the Instructional Development Office (IDO), specifically charged with "bringing information technology to bear on the educational mission of the University." One specific activity sponsored by the IDO and supported by a two year Virginia State Council of Higher Education Funds for Excellence Grant ("Infusing Technology into Teaching, Learning and Community") is the "Pioneer and Guides" program:

The Pioneers: New-Technology Based Courses. Faculty who wish to develop a dramatically fresh pedagogy, based on information technology, need encouragement to reevaluate their teaching practices, assistance during the process, and, most importantly, time to develop their courseware. Six faculty in 1994-95 and four faculty in 1995-96 were selected for extended IDO support, based on three criteria: willingness to experiment, the number of students to be affected, and the potential success and visibility of their project. Pioneers received a stipend for summer work and one course-release during the academic year, plus the support of an instructional designer, graphic artists, and technical staff.

The Guides: Technology-Enhanced Courses. It is neither practical nor wise for the majority of faculty to act as Pioneers. However there are increasing numbers of faculty interested in learning about successful experiments and exploring possibilities of activities that might be modified and/or incorporated into teaching to suit their students. To support and encourage this interest, the IDO recruited the Guides, eight faculty in 1994-95 and four in 1995-96. They offered discipline-based workshops, conducted software and database reviews, developed their own homepage with appropriate discipline-based links, and fostered the integration of technology with individual faculty colleagues (one-on-one) or in group seminars and discussions. Guides also received a summer stipend (1995) and course reduction over the semester as appropriate.

Conclusion: Even if it exists, the espousing of the benefits of newly available technology by university administrators cannot sufficiently foster the development of the necessary faculty driven application of technology to learning. The Instructional Development Office of George Mason University implemented a successful program designed to support and encourage its faculty in their efforts to respond to the imminent changes in the nature and format of teaching and learning.
The Mediator implementation of the learning web is described by Norrie and Gaines [1995]. This short note illustrates some of the tools. WebGrid [Shaw and Gaines, 1995] is an implementation of a repertory grid elicitation program as auxiliary server on the web, using HTML forms to support an elicitation dialog with the user (Fig. 1). Fig. 2 shows a cluster analysis of the grid elicited being fed back to the student. WebMap [Gaines and Shaw, 1995a,b,c] is a concept mapping tool that has been interfaced as a client helper to web browsers to allow concept maps to be edited and issued as clickable maps on the web (Fig. 3).

Figure 1 WebGrid initial entry screen
Figure 2 WebGrid FOCUS cluster analysis

Introduction

George Kelly was a clinical psychologist who lived between 1903 and 1987, published a two volume work defining personal construct psychology in 1955, and went on to publish a large number of papers further developing the theory, many of which have been issued in collected form (Mead, 1969). Figure 1 attempts to encapsulate the historic forces at work in psychology, logic, cognitive science and artificial intelligence before and after Kelly's work.

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[Diagram showing computer generations and psychology-related topics]
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As Internet access and global networking become more mainstreamed, we could find our society segmented into two groups who are unable to communicate with each other: The information "haves" who will be capable of accessing and using information productively and the information "have-nots" who will be prisoners in our own society.

In an effort to narrow the gap between the information haves and have-nots, the Underserved Families Internet Research Project focused on that group of people who are likely candidates for the have-nots. This group, the traditionally underserved, included minorities, families from low socioeconomic areas, and those with limited English proficiency. The primary goal of this project was to study the barriers to and ramifications of providing Internet access to the traditionally underserved. In achieving this goal, we identified: (1) strategies, activities, and materials that can be used to encourage entry into technology by the underserved; (2) barriers to access; and (3) the support services required for this group's continued participation.

Six families from the local community were selected to participate in the project. Using equipment from our home-computer loan library, participating families were loaned a computer and a modem and were trained to use this equipment. Families also underwent Internet-based training. Among others, families were taught how to use the Internet to communicate electronically with each other, resource searching strategies, and how to acquire information from the Net. The Internet connections consisted of PPP links provided by the university at no direct cost to the participants.

Our preliminary findings suggest that home computer and home Internet access can: help change the image of underserved parents about their role in education; raise the level of awareness of underserved parents about global networking; and provide underserved parents with practical, first-hand knowledge about technology and give them the technology-based experience required to become technologically literate. It was also discovered that underserved parents developed proficiency in using telecommunications hardware and software, and used local and global resources to assist in the lifelong learning of themselves and their children.

School and research personnel volunteered their time to implement this project and equipment donations were made by local businesses in support of the project. As an extension of this project, we are now examining the potential benefits of extending this project into the community at-large by setting up several urban community centers to serve as Internet points of presence for other members of the underserved community.
1. Introduction and Motivation

Many teleconferencing systems use application sharing to allow multiple users each on their own workstations to view and interact with a single application. The most critical aspect of an application sharing is its synchronous that limits the collaboration only during the work session. A key aim of our work is to develop a method that allows asynchronous view and discussion about practical exercises. This is provided by X-session recording and replaying services which are used to build an efficient asynchronous interaction between a professor and a student.

2. X-Application Session Replay

X-Application Recording Service: In order to record the X-application session, the relevant information about the X-student’s session should be recorded. The analysis of the execution mechanisms of an X-window application implies that the requests sent by an X-application to the X-server are key messages that allow the Graphical User Interface (GUI) of an X-application to be generated. These messages are timestamped, grouped and stored in a request database. A storage policy of requests should be applied to structure the X-student’s session especially when the X-application is with a multiple process model.

X-Application Replaying Service: The replaying of an X-application is done by replaying stored requests on a remote X-server. The replaying service has to accomplish two main tasks: converting and scheduling stored requests. To perform convenient conversion an X-protocol translator is needed. This translator converts the attributes of requests to the ones accepted by the remote X-server. The main attributes subject to conversion in our case are resource identifiers and pixel values. These problems are described in more detail in [Abdel-Wahab et al. 1991]. The request scheduling resolves the precedences between requests and the relationship between different history queue of requests. This allows for replaying requests with respect to their timestamps and their groups. Timestamps serve as a references which allow a flexible replaying of an X-application session.

3. Improving X-session Replay with Selective Replay

The replaying of a global X-application session seems to be heavy in special cases. In fact, if the problem encountered by the student occurs two hours after having run the X-application, then the professor would wait almost two hours to perceive the student problem. To cope with this problem we should allow a selective replay of an X-application session. This selective replay can be provided by using a method of dynamic participation in a teleconferencing system as described in [Chung et al. 1993]. Using this method we introduce a revival points in the student’s X-session. These points serve as dynamic access points from which we can replay a specific portion of the X-session.

4. References


Visual Programming in Smalltalk

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A Visual Smalltalk Browser

With the shift towards multimedia in most computer applications, attempts have been made to test whether visually based software development environments would have advantages over conventional text-based environments. We selected Smalltalk to implement a new type of such an alternative environment. Our ultimate goal is to test what advantages a graphically based environment might have over a textual one but although the environment is now fully operational, we have not yet performed any formal comparisons with its conventional textual counterpart. The reasons why we selected Smalltalk for the experiment are its uncompromising object orientation, availability of all source code within the environment, extreme ease of experimentation due to the modifiability and extendibility of its library, and the fact that Smalltalk does not require lengthy compilation and linking during application development.

The conventional Smalltalk program development interface - the browser - is textual but implementation of an alternative GUI is relatively easy because the source code of the browser is a part of the library, along with methods for generation of graphics and the code of the compiler. Creating a new user interface thus only requires designing a graphical representation of Smalltalk code and modifying the existing browser to allow display of code in either textual or graphical format.

The visual browser was developed by the first author as a part of his MSc thesis and an illustration of its user interface is shown in Figure 1. The illustration shows that two radio buttons have been added to the standard browser to make it possible to select either the conventional textual representation (not shown) or the graphical representation, and switching from one mode to another automatically changes the display. The format used for display is independent of the style used to develop the program.

Figure 1: Modified VisualWorks browser showing a method declaration in Visual form.
Letting Learners Be Learners: Combining Constructivism and Computer-based Instruction

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A major principle of constructivist learning theory is that learning is an active process in which learners construct new ideas or concepts based upon their current knowledge. In terms of instruction, the context and problem should encourage students to discover principles by themselves. The implication for computer-based instruction is that learners need the freedom to explore the content and create their own cognitive map. The application should not include forced paths, dead-ends, or infinite loops where the only way out is to enter a correct response to an activity.

Learning is enhanced when information and instruction is presented in context of things with which the learner can personally identify. The degree to which we can weed out irrelevant facts and get to critical issues determines the amount of optimized learning we can achieve in the same amount of time. Based on these criteria, the ENACTS multimedia-based simulation environment (MBSE) is an example of how to combine constructivism and educational technology.

The ENACTS project sponsors were not interested in traditional approaches to training. The solution had to transfer quickly on the job; any additional job aids that were not naturally apart of ENACTS were unacceptable. They also wanted individuals to take more control of their learning and not be reliant on others to spoon-feed them. The ENACTS MBSE training development team was charged with developing a learning strategy that allows the learner to use the actual databases, including interactions that are relevant to the work the learner does everyday. The learner should be aware of the content of and context in which to use each database.

In response to sponsor requirements, the ENACTS MBSE provides a non-linear, learner-controlled method of building skills in using to use the requisite databases and tools. Learners explore three graphical office environments and work with graphical, on-line teammates to access information and complete activities. Within the office setting is typical office equipment that ‘functions’ just as it would in an actual office. There is no set path through the course and correct responses are not required to move between activities. The on-line teammates provide tips and guidance regarding responses to activities as well as a suggested activity sequence. The course includes fifteen activities and requires approximately six hours to complete.

Learners who are free to roam the MBSE environment find the content with which they identify, develop their own cognitive strategies and maps, and spend more time actively engaged in the learning process. Learning will be the constant if the learner is engaged. Given this autonomy, learners can develop mental models to provide meaning and organization to the learning experience and delve beyond surface-level information. Learner immersion in problems that are relevant to their lives, combined with resources to guide their experience and enable them to complete activities, can result in robust and effective computer-based training programs.

At first, it may be disruptive or difficult for the learner to accept the change in their electronic self-study paradigm, in terms of knowledge transfer and skill building the results prove its effectiveness. Making the situation engaging and relevant to target learners, giving the learner access to necessary information while providing supportive and relevant coaching/scaffolding, and including authentic assessment and feedback, can assure that computer-based education products put the learner first - and let learners be learners.
Partners in Cognition: Problem-Based Learning With Computers

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It is now generally accepted that learning is a constructivist process in which students are actively involved in the creation of knowledge by restructuring their existing mental schemata in the light of new information. At university level, there is a great deal of interest in the creation of educational environments to support constructivist learning. Many of these environments include computers.

The subject of the study is a one-year unit in the post-graduate Architecture program at the University of Hong Kong, in which students worked in small groups in a computer laboratory to produce interactive three-dimensional models of building systems. The projects involved real-world problems such as a maintenance model for a Hong Kong curtain-walled building, an educational VR model of a Tang Dynasty temple and a morphing system to illustrate the historical development of roofing structures.

Using predominantly qualitative research methods, we set out to ask the question: "In a problem-based, constructivist learning environment, what is the relationship between student characteristics, computers and cognition?" The tools included videotaped talk-aloud protocols, cognitive mapping with Pathfinder networks and the Study Process Questionnaire. Analysis was carried out using the NUD•IST software. Four interlinked issues have emerged which appear to be central to successful "cognitive construction" in this type of environment.

- Approach to learning: a "deep" approach to learning — as measured by Biggs' (1992) Study Process Questionnaire — was a characteristic of students who had successful strategies for working with computers;
- Acquiring structural knowledge while declarative and procedural knowledge of both architectural and computing domains was a stated objective of the course, structural knowledge emerged as the core issue in successful completion of the projects;
- Metacognitive awareness for efficient functioning of the group it was essential that students were aware of their own and other's strengths and weaknesses in both declarative knowledge and procedural skills and had definable strategies for acquiring new knowledge and skills;
- Distributed cognitions: sharing of knowledge and skills was a characteristic of this working environment, so much so that it appeared to be the only feasible way of approaching the task; the most successful project groups accepted the computer as a "partner" in distributed cognition.

By the end of the exercise, many students were conscious of the computer having affected the ways in which they approach a task and go about achieving it. Salomon (1993,3) differentiates between the effects with and effects of computer tools: "… working with an intelligent tool has effects on what students do, how well they do it and when it is done", whereas effects of the technology refers to perceived "changes in mastery of knowledge, skill or depth of understanding once the student is away from the computer."(Salomon, 1993,3)

This paper represents work in progress, to aim of which is to establish whether the experience if working with computers leaves any cognitive residue in the form if improved ability to conceptualize a form or a space, or to communicate this information in the absence of the computer.

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Learning With Hypermedia: What User Do and How to Observe it Automatically

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Direct or system-controlled observation of user actions is a common method to examine computer-supported learning processes. An increasing number of systems is equipped with automatic event logging and protocolling tools. Very few systems, however, support the analysis and the interpretation of data. We suggest a simple grammar of actions, that allows both complete data collecting and fast data processing. Protocols can be obtained by direct observation, video observation, more or less formal interviews or self-reports of the users. Among these methods automatic generation of interaction traces is advantageous: Data are collected easily and the measurements are not influenced by human researchers [Hasebrook 1995]. The comparison of several protocol formats leads to some assumptions, namely: (1) The protocol should focus on user actions and not so much on system events. (2) The protocol should be both complete and fast to process. (3) The protocol should provide information about actions, their origin and their interrelation. (4) The protocol should allow selections as well as summaries and therefore provide information about both details (e.g. number of lines in a text field) and meta-classes (e.g. all navigational tools).

Actions and their relations are best described by a grammar with the following characteristics: (1) The user actions should be clearly classified and be built up from atomic events like ‘forward’, ‘backward’ etc. Classes and meta-classes should be defined as compounds of atomic events, e.g. ‘Paging’ = \{forward|backward\} and ‘Navigation’ = \{Paging|Browsing\}. (2) The protocol should store user actions and all necessary attributes as ‘normalized’ data. Normalizing a database is a standard procedure to make a database non-redundant and consistent. (3) The information of an object stored in the database should support further data analysis. Important information are: How many atomic events form a certain user action? What kind of data and how many items are related to an object? We want to demonstrate the use of automatically processed protocols with an example from our research [Glowalla and Hasebrook 1995, pg. 107].

Table 1: Percentage of users that use a particular tool (and percentage of high acceptance) as a function of study setting and user skills.

<table>
<thead>
<tr>
<th></th>
<th>Learning</th>
<th>Relearning</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>unskilled</td>
<td>skilled</td>
<td>Accept.</td>
<td>unskilled</td>
<td>skilled</td>
<td>Accept.</td>
</tr>
<tr>
<td>Navigational tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paging</td>
<td>100%</td>
<td>100%</td>
<td>(100%)</td>
<td>100%</td>
<td>100%</td>
<td>(100%)</td>
</tr>
<tr>
<td>Browsing</td>
<td>11%</td>
<td>9%</td>
<td>(90%)</td>
<td>9%</td>
<td>20%</td>
<td>(77%)</td>
</tr>
<tr>
<td>Informational tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contents</td>
<td>49%</td>
<td>38%</td>
<td>(53%)</td>
<td>30%</td>
<td>42%</td>
<td>(41%)</td>
</tr>
<tr>
<td>Glossary</td>
<td>49%</td>
<td>68%</td>
<td>(94%)</td>
<td>20%</td>
<td>18%</td>
<td>(86%)</td>
</tr>
<tr>
<td>Clipboard</td>
<td>9%</td>
<td>3%</td>
<td>(41%)</td>
<td>20%</td>
<td>20%</td>
<td>(60%)</td>
</tr>
<tr>
<td>Mean</td>
<td>44%</td>
<td>44%</td>
<td>(76%)</td>
<td>36%</td>
<td>40%</td>
<td>(73%)</td>
</tr>
</tbody>
</table>

High acceptance = Percentage of users (52 learners, 43 relearners), who judged a tool as ‘helpful’. Performance = Percentage of users, who used a certain tool.

As can be seen in table 1, performance measures differ as a function of the different conditions: Browsing tools were used most often - but not preferred - by skilled relearners, informational tools, however, were used more often during learning than during relearning - a fact that is reflected in the acceptance rates. In conclusion, the significance of acceptance rating cannot be evaluated without appropriate performance measures.

References
Development of educational software has had a long history of use of authoring environments that have enabled instructional technologists rather than programmers to design and develop applications. The advantage of these tools has been that the designer did not need to be highly skilled in high level programming languages, but could use a simpler instructional set and pre-programmed modules. The disadvantage was that the developer was limited to the pre-programmed modules available and to the underlying assumptions of highly structured instructional design models. Lack of cross-platform development avenues, slow authoring and delivery speeds arising from the need to operate through the authoring environment's interpretative layer are illustrations of other existing constraints.

A multitude of authoring tools such as Authorware Professional, ToolBook, Oracle Media Objects, Macromedia Director, Mtropolis, Digital Chisel and HyperCard have been developed. Many of these packages have a constraining model of how they present information and manage interactions. Authorware's flowchart representation of structure and presentation, Director's multiple windows and development stage and HyperCard and Oracle Media Objects screen-based construction metaphor have been developed to empower instructional technologists but their constraints make it difficult to effectively produce multimedia titles reflective of constructivist, instructional goals.

[Driscoll, 1994] provides this list of five instructional design goals for a constructivist learning environment.
1. Provide complex learning environments that incorporate authentic activity.
2. Provide for social negotiation as an integral part of learning to allow insights to emerge through the group process that may not come about otherwise.
3. Juxtapose instructional content and include access to multiple modes of representation to allow learners to examine materials from multiple perspectives.
4. Nurture reflexivity, or awareness of one’s own thinking and learning processes.
5. Emphasise student centred instruction, where students are actively involved in determining their own learning needs and how those needs can be met.

The development of guidelines based on these sets of values represents a strategy for summarising the constructivist framework in a way that can lead to a wide variety of learning environments and further provides a basis for evaluating instructional strategies. Essentially these values are concerned with epistemology and how we come to “know” about the world.

With the current demand for cross-platform applications and the need to have high performance, in terms of speed and features, the Interactive Multimedia Learning Laboratory team set out to develop a software development environment that would satisfy these needs and also not constrain the instructional design models used.

It was envisaged that the development environment would facilitate the production of complex learning environments, ie this would be an authoring tool that offered complete flexibility in the design process and also high level performance on entry level machines.

The key elements of the authoring environment, termed MediaPlant, are that the tool includes:-

- rapid prototyping of design ideas and restructuring of ideas simply and efficiently.
- design elements that can be added through either menu selection or copy and paste facilities
- design elements that can be edited, reused, and repurposed simply and efficiently
- hypertext linking from element to element
- extensibility so that new features can be added when necessary
- visual representation of the application and the authoring environment available at all times.

The authoring environment consists of a development program and a runtime program. The development program is used to construct and test the product, and this is then compiled as a runtime version. The
development program is Macintosh based with runtime packages being developed for either platform. The software environment is based on a C++ application framework tailored for large scale multimedia development. MediaPlant has facilitated the development of an extensive learning environment which largely reflects the instructional design goals of Driscoll (see above). Authentic activity has been achieved by employing familiar, real-world metaphors such as a river environment and a research/resource centre.

Shifting The Paradigm As Schools and Technology Improve

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Will technological improvement in the classroom make full use of enabling technology available in the marketplace, such as infrared connectivity and emerging Internet tools?

Manufacturing, software, and other industry partners are vital to a healthy educational community. Industry commitment must include both engineering of form factors and software to meet student needs and marketing strategies that fit school budgets. Industry partners win through success in the educational market and through ensuring a well prepared future work force.

As an example, Hewlett-Packard Company, Oregon Department of Education, and three schools are experimenting with placing wireless Internet connectivity in the hands of varying proportions of students in five classrooms.

Will school reform efforts fully recognize and support technology in the classroom?

Many Oregonians are working toward a vision where the answers to these questions are yes. Grass roots classroom technology innovators are now collaboratively working with a statewide systematic effort called the Oregon Public Education Network.

The Oregon Public Education Network (OPEN) is pushing to bring high speed Internet connections to all school buildings in the state by April 1998. Currently 400 of the 1200 schools are connected. The training and instructional arm of OPEN (called OPENing) is assembling “starter kits” for teachers. The goal of OPENing is to help every teacher become successful in integrating telecommunications technology across the curriculum.

In a February 1996 survey, teachers throughout the state requested professional development in technology consistently over other types of training. The Earth and Sea Investigators’ Program (http://www.sce.ojgse.edu/earthsea/) is one statewide program that offers teachers individualized support in technology and instructional strategies through classroom visits, telephone help-line, electronic mail, and the worldwide web.

The Earth and Sea Investigators’ Program utilizes several types of technology for delivery. For example, Oregon ED-NET’s 2-way interactive satellite delivery is used to connect teachers with professional development and to connect students with scientists. Through an e-mail address supervised by a certified teacher, electronic mail is used to connect a suite of scientists with students requesting help with scientific research projects defined by the students. The worldwide web is used to provide extensive content on selected topics (“Topics to Explore”) and HyperNews pages, which thread questions and contributions from hundreds of students throughout the state engaged in self-initiated scientific research projects.

Acknowledgements

Special thanks to Norma Paulus, Oregon Superintendent of Public Instruction; Mary Beal, Susan Lynds, and John Sechrest, Oregon State University; Joanne Flint and Wanelda Masters, Oregon Department of Education; Diana Byrne and Charlie Patton, Hewlett-Packard Company; Tom Cook, Oregon Public Education Network; Shain Glenn, Roberta Hutton, Michael Nicholson and Steve Travis, Consultants; Thom Hayes and Gail Whitney, Oregon Graduate Institute; Judith Vergun, Native Americans in Marine and Space Science, Oregon State University; and the students, teachers, and administrators at Siletz Elementary, Sunset Elementary, and Taft Elementary/Middle School participating in the wireless telecommunications experiment. This project has been supported in part by Networking Engineers Researchers in Oregon, Oregon Department of Education, Oregon ED-NET, Oregon Space Grant, Oregon State University Hatfield Marine Science Center, and Tektronix,
1. Introduction

Based on researching on multi-user interface [Dewan and Choudhary 1992] and CSCW (Computer-Supported Cooperative Work), this paper constructs a distributed distance education environment by designing its scene layout-switching graph and MISL (multi-user script language) programs. This learning system can provide more than one course held at the same time with four learning modes [Chan et al. 1993]: lecture, discussion, test and self-education.

2. Interactive Script Architecture

In this environment, an interactive script control is proposed as a dialogue mechanism to manage the switching of operation environments. Accordingly, a scene layout-switching graph is designed and one kind of distributed system language, MISL, is developed for CSCW systems.

![Interactive script architecture](image_url)

Figure 1 Interactive script architecture

There are two basic elements in the interactive script: tool and scene. A tool is an application program, with some specific function, such as textbook and audio phone. A scene is an operation environment, with a set of windows of application tools executed in a screen. To specialize the scene switching in a CSCW system, a special set of tools (programs), such as button and menu, is defined as control tools. The switching commands emitted from control applications are called control messages. When a control tool receives control message from its local user, its screen will be switched; if necessary, the screens of other remote users will be changed accordingly. Then, the scenes of different computers are able to be operated synchronously to let the users to cooperate (even compete) to achieve their common goal. Figure 4 shows the interactions and messages of the
Proposed model.

![Figure 2 Scene layout-switching graph](image)

**Figure 2** Scene layout-switching graph

```plaintext
BeginScript(
[Resource]
  Path xxDistEdu
  ...
Scene [Lecture]
  Load Distance "500,540,100,50"
  ...
  Load Textbook "book,0,400,350,BCCbook"
  ...
SwitchCondition
  if select Discuss then
    SwitchTo [Discuss]
    RemoteMessage [Lecture] button Discuss
    Hide Textbook
    ...
  endif
EndScene [#Lecture#]
Scene [Discussion]
EndScript
```

**Figure 3** MISL script program

Practically, the MISL interpreter and other components, such as integrated coordinator and real-time multimedia tools [Lin et al. 1995], are investigated to accomplish a complete CSCW system.

3. Distance Education Environment

The distance education system is built on more than two computers, one for the teacher and others for students. There are two kinds of scripts: teacher's and student's, with several learning scenes. This system is implemented on PC (Personal Computer) platform with MS-Window NT/95 operating systems. Since TCP/IP protocol is followed, both WAN (Wide-Area Network) and PSTN (Public Switching Telephone Network) can be the communication channel. Moreover, the media used are text, audio and image.
4. Conclusion

This paper analyzes multi-user interactions and interactive script interface model of CSCW systems, then a distance education environment with several learning scenes is developed. Since the current research focuses are mostly placed on the implementation techniques, more work should be done in the near future to experiment its effectiveness.

References

Using the World-Wide-Web to Promote Faculty Development in the Use of Technology

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Faculty in the School of Education at the University of South Dakota are becoming skilled in the design and production of World-Wide-Web (WWW) home pages. The final products are being used for instruction in many of their classes, as well as for their research and service projects. This opportunity has been made possible because of the research and development initiative in the School of Education focusing on the new use of emerging technologies.

Faculty members are selected, 1-or 2 from each of the four divisions in the School of Education and assigned part-time each semester to the Center for Interactive Technology in Education and Corporations (InTEC). Those faculty members spend time enhancing their skills in designing instructionally-sound materials and in researching new strategies and methodologies for the delivery of instruction, especially in the telecommunications field. As part of their professional development, they are also challenged to learn how to use new and emerging technologies as a component of the delivery system. As part of the overall experience, faculty are expected to be involved in developing WWW home pages which can be applied to an area of study or content specialty.

InTEC at the University of South Dakota was established in the School of Education as a matrix organization implemented for interactive technology research and production. It was originally staffed with a director and several faculty released on a rotating basis from each of the four Divisions on a part-time basis, with the focus being on the applications in education and training of advanced interactive technologies, particularly digitized video.

The successes of InTEC are numerous. Specific examples include a) networking all the offices and classrooms in the School, b) the ongoing noon seminar series for faculty development sponsored by InTEC which presents information and/or training for faculty on multimedia software applications or special topics like WWW development, c) special grant-funded projects such as the pressing of a CD-ROM for special educators to use in their training about inclusion, d) using CU-SeeMe software for advising and instructional duties, e) working with campus Dept. of Anthropology to create material for public school teachers about archeological digs, and f) making several digitized movies for legislative and business presentations, regental meetings or campus organizations. As a result of these and other efforts, faculty development opportunities in multimedia production have taken a leadership role in promoting distance education initiatives for the University of South Dakota as a whole.
Examples of faculty WWW home pages can be found at the following address: (http://www.usd.edu/ed). Other interactive multimedia examples and further illustrations of the School of Education's efforts and commitment via telecommunications can be accessed through the USD WWW home page.
A Study Of Cognitive Effectiveness On Computer-Assisted Learning

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Computers are gaining prominence as a major learning tool in education settings. Since design of courseware needs to be sufficiently delicate to maximize the learning effectiveness, cognitive variables influencing learning outcomes in a computer-assisted learning (CAL) environment are worth investigating. Generally, learning outcomes depend on the quality of computer courseware as well as learner characteristics and learning environment. The major purposes of this research are to examine: (1) the learning effectiveness for students of different characteristics (FD/FI or aggressive/submissive) in different learning environments; (2) the learning effectiveness of graphic, sound, text, window, icon, menu, animation, color for students with different characteristics, and (3) the error pattern and pathway for students of different characteristics using different discovery approaches (goal-oriented vs. guided oriented discovery strategy).

Teaching concepts from real life needs is current science education emphasis [see Evertson & Murphy 1994]. Hence, the first phase of this study is to develop a courseware designed from real life examples. As described in [Posner 1986] stimulus and intellectual orientation can play an important role in the cognitive process. According to [Reason 1991], learners with different knowledge bases probably have different choices or matching styles. This fact explains why learners have different pathways and error patterns. The current pathway and error pattern will influence subsequent pathway and error pattern. [Reiber 1992] classified discovery approaches into goal-oriented and guided-oriented. Goal-oriented discovery approach is rooted from the instructivism philosophy; while guided-oriented discovery approach is originated from the constructivism philosophy. Based on the theoretical framework mentioned above, this research is intended to examine the interrelationship among student characteristics, computer-assisted learning environments, knowledge domain, student cognition, and student affects.

This three-year integrated study, sponsored by the Chinese National Science Council (NSC), consists of 7 projects, regarding "the effect of learning psychology in CAL environment" is to explore the science knowledge acquisition of students for elementary schools or junior high schools. Two of them explore the pathway of concept development and error pattern for learners on discovery CAL learning environment, the rest five projects study on the effectiveness of HCI design (text, graphic, sound, image, and animation) on discovery CAL learning environment respectively. This project can be divided into three major stages: (1) to develop a real-life scenario to design the goal discovery strategies, (2) to proceed the field test of goal discovery and to analysis the pathway of concepts development and the error pattern of learners in different HCI (human-computer interface) design, (3) to design and proceed the guided discovery and to analysis the pathway of concepts development and the error pattern of learners.
The experiment and data collection of this study is still in progress. The research findings will help theory building and solution forming. The findings will contribute to theory building in CAL courseware design and provide solutions with practitioners in selected subject domain.

References


Figure 1  Adapted from : Poser, M. I. (1986). Chronometric Explorations of Mind. New York: Oxford University Press.
The course chosen for a pilot project

A Classical Studies course, The Beginnings of Science, was chosen for this project because presentations can be enhanced by diagrams and illustrations and because many Classical texts and resources are available on the Internet. Students were required to research a topic, make an oral presentation to the class and produce a web page (instead of a written paper), with both content and design of the page considered for their grade.

Irwin gave the class a short questionnaire asking about students' computer and Internet experience. Of the eleven students in the class, most were comfortable with computers, but few had Internet experience, and none had written a document in HTML.

Instruction on using the Internet

The library with its newly updated computer lab and its commitment to making academic information on the Internet accessible in the College was a natural partner with the teaching programmes of the Division of Humanities in this project.

Patterson led a hands-on workshop on finding Classics resources on the Web. This included locating scholarly electronic journals and academic institutions, carrying out keyword searches, and troubleshooting. Students were required to hand in an assignment (an Internet hunt) as part of their grade.

Two weeks later Patterson led a workshop on writing in HTML. Students were given an overview of the language using a program called World Wide Web Weaver. They were shown features of Netscape demonstrating how to learn from others' pages, and were provided with a handout (obtained from the Web). Students were asked to produce and submit a personal Web page.

A month later two two-hour sessions were held to assist students in writing up their academic work on Web pages. Students learned about obtaining graphics from the Web, appropriate HTML for specific design concerns, and technical issues of working on HTML documents in two places (home and at the College's computer labs). At this session, students had access to a high-quality scanner.

Conclusion

Lack of access to full computer labs occasionally frustrated students. (This was the reason for increasing the number of workshops with technical assistance available). The project makes heavy demands on the instructor. This group was small so that the number of questions was never onerous. The development of new HTML editing tools may ease the demands somewhat.
For both students and instructors, the pilot project was a strong success. Students produced documents of high quality, in both content and design. We will be demonstrating some of this work in June.

Acknowledgements

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A Hypermedia-driven Computer Assisted Mathematics Remediation Package: From Prototype to Problem Shell with Tracking Mechanism

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This paper will describe progress on a computer-driven mathematics remediation package which is in its fourth year of development [James & Taplin 1994]. Recent additions have included the creation of a general-purpose problem input shell and a problem-solving tracking mechanism.

The package was developed to address deficiencies in the mathematics skills of pre-service primary and early childhood teachers. The aim was to produce a teaching medium which can be administered to individual or small groups of students, will teach basic problem-solving skills and knowledge they need to become effective teachers of mathematics, will cater for four preferred formats for representing solutions (sentences, equations, two-dimensional representation, and three-dimensional representation), will be self-paced, and will allow for the monitoring of student progress. Figure 1a is a snapshot of one page which demonstrates the “point and click” nature of the user interface.

The preliminary version of the package required problems to be input by a HyperCard programmer. However, a major improvement was the establishment of an icon-driven shell into which teachers can put their own problems. For this, the teacher invokes the Problem Generator.

It is useful to be able to monitor students’ work and to have insight into the way they manage the use of strategies and heuristics. Therefore, a further enhancement was the introduction of a mechanism for recording the user’s path when problem solving. The tracking mechanism consists of HyperTalk code which records on a text file each action the user takes when solving a problem. It runs in the background as the student uses the problem-solving package. See Figure 1b for an example of the tracking output file format of one user’s problem-solving session.

Currently, there are two separate areas of investigation being undertaken. The first is an evaluation of the impact of the tutorial on problem solving skills. The second uses the tracking system to analyze patterns of use of the tutorial by successful and unsuccessful students. The whole project is now in a vigorous phase of trial and analysis.

note: a full version of this paper and the computer package (Mac/HyperCard) are available from authors.

Reference

Universities worldwide are implementing new technologies into their curricula for a variety of reasons; cost-effective teaching and learning, enhanced learning environments, distance education media, and preparation for integration into the "information superhighway".

Hong Kong Polytechnic University (PolyU) has recently embarked on a major commitment to developing and implementing interactive multimedia technologies (IMMT) across The University. This paper will relate critical issues of the strategic plan for implementing IMMT.

PolyU formed a Working Group on Modern Educational Technologies which had wide university representation. After several meetings, it was agreed to fund the following:

1. equip some classrooms with multimedia equipment, including video and networking facilities,
2. set up student electronic bulletin boards in all academic departments accessible from home or campus, allowing student/staff interaction, electronic assignments, and library access, and
3. provide the facilities and funding for academic staff to develop CAL packages, with the goal of implementing IMMT across the curriculum.

The final outcomes listed above are the result of a strategic plan used to identify, justify, and implement these technologies. The strategic plan can be divided into two main categories- general aspects, and particular planning steps. General aspects were:

1. to create an environment which contributes to the enhancement of teaching and learning quality via IMMT while increasing the cost effectiveness of the teaching/learning process,
2. in the development of materials, current technologies and modern learning theory will be used, and
3. to focus on cultural aspects of implementing IMMT and take steps to help faculty adopt and implement new technologies; this includes ensuring that The University adopts flexible rules and regulations on course design and teaching arrangements.

Particular planning steps of the strategic plan included:

1. utilize CAL packages by purchasing existing appropriate packages and by developing in-house software which will require funding multimedia hardware and software,
2. utilize telecommunications facilities by upgrading existing networks, and creating electronic bulletin boards and video conferencing facilities,
3. establish committees on teaching and learning both University-wide, and within departments, and
4. ensure a financial commitment from both internal and external sources.

In response to a call for submissions for IMMT projects, there were twenty-six proposals from forty-eight staff members requesting nearly HK$8 million. There were eight successful submissions from a cross section of departments.

As a response to the availability of interactive multimedia technologies, The Hong Kong Polytechnic University has drawn together a wide representative group to formulate a plan for utilizing these technologies and developing resources in order to improve the overall quality of teaching and learning. The strategic plan is intended to ensure that faculty and developers have the supporting infrastructure needed to give such a venture every chance of success.
We believe that in a world of information overload, students need to be taught to process and communicate information in a dynamic non-linear manner. Training students to use multimedia can facilitate this goal.

However there are problems with the use of multimedia. The tools available today don’t help the students with what we believe to be most important, processing and communicating information. The authoring tools available make it possible for students to combine media into a glitzy presentation but they don’t help the students to synthesize the information and to think and communicate in a non-linear way.

We are designing The Multimedia Mentor, M³, a tool that will act as a cognizant advisor, an aide, facilitating the students through the process of asking questions, answering questions, and communicating information. It is an interactive system that is an integral part of the authoring tool. M³ does this three ways.

First, M³ has a help system that focuses on knowledge manipulation strategies. When the student clicks on the “Now What” button, M³ suggests what the student should be thinking about and how to think about it. It is specifically designed to help them identify and achieve their overall goal of the project, as well as how to develop questions that will reveal the interconnectedness of the information.

Second, M³ allows the student to better focus on the information by automatizing some of the mechanical aspects of the project. For example, in some authoring tools linking two pieces of information requires approximately seven steps. M³ does this in one to two clicks. When a student creates a button they are given a list of cards in the project and they then have the option of linking the button to one of the cards or creating a new card.

Finally, M³ keeps track of what information is in the project and presents it in a visual manner that allows the student to keep track of what ideas can be related to one another.

For multimedia to assist students in processing information there needs to be a tool that will assist students in keeping track of what information is in a project and how it is connected. We believe The Multimedia Mentor is that tool.

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Courseware authoring method for ITS on WWW

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Introduction

The World-Wide Web, is normally used for general information purposes. However, it can also be used as a platform for distance learning systems because of its multi-media hyper links. Some Intelligent Tutoring Systems (ITS) have recently been constructed on the World-Wide Web [Omatsu et al., 1995][Schwarz et al., 1996][Nakabayashi et al., 1995]. By providing adaptive hypermedia, these systems can guide students through the courseware. On the other hand, to produce courseware for ITS on the WWW the authors must write both the normal HTML text and the ITS control scripts. To solve this problem, we proposed a courseware authoring method that consists of HTML-based notation in which ITS control commands are embedded (HTML-ITS) and a process that converts this notation to run-time courseware for CALAT [Nakabayashi et al., 1995] using a common courseware structure. This method eases production of courseware for ITS on the WWW because it contains less description and the ITS control is simpler.

HTML-ITS notation

In our method for embedding the ITS controls in HTML text, we used no extensions for HTML grammar in order to allow existing HTML authoring tools to be used. HTML-ITS consists of a declaration part followed by several block notes beginning with the key word: "<HR>ITS:". The title of the courseware and, if necessary, definitions for ITS are written in the declaration part. There are two sorts of block notes: explanation blocks where teachers explain the topic and Q & A blocks where teachers test the students. The order of blocks corresponds to the order in the scenario of the courseware. Therefore, if there is no special control by ITS, elements will be presented in this order.

HTML-ITS conversion to run-time courseware

During the conversion from HTTP-ITS to run-time courseware, the HTML files are created by dividing the explanation blocks and the Q & A blocks into files with automatically assigned names, and the ITS control scripts are also created with a common courseware structure made by studying existing courseware written by expert authors. Other information specifically related to the courseware is first resolved by the embedded ITS control commands, and next by the structure of the explanation blocks and the Q & A blocks. By using HTTP-ITS and these conversions, the total amount of description for the courseware is much reduced.

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Evidence-Based Advising

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The goal of the Evidence-based Advising (EBA) project at the Institute for the Learning Sciences is to help learners improve their ability to perform informal critical reasoning in the context of important social policy issues. In particular, the EBA project focuses on helping learners recognize whether or not an opinion is supported by reliable evidence and improve their ability to support their own opinions with reliable evidence. Our approach is to create Goal-based Scenarios—authentic software environments in which learners are placed in a motivating situation, given a realistic role and asked to complete an important task. The scope of the EBA project includes the development of three applications in three different subject matter areas: international relations, earth sciences and statistical reasoning. We are also building a tool which will allow content experts to build custom EBA applications.

In an EBA learning environment, the learner plays the role of an advisor to an important decision maker and is asked to create a report evaluating several alternative solutions to a given problem. For example, the learner may be placed in the role of an advisor to President Kennedy during the Cuban missile crisis and be asked to evaluate several options for responding to the Soviet threat. To help complete the task, the learner is given a large hypermedia database of information and expert opinions about the issue, a skeletal report, and a panel of opinionated experts who represent conflicting perspectives about the issue. Upon submitting the report for review, the learner receives a critique which focuses on the quality of the evidence she used to support her conclusions. The learner can then revise and resubmit the report. There are three aspects of the architecture which are worth highlighting: the learner's role as an advisor, the construction of the report and the panel of advisors.

Why have the learner play the role of decision maker, instead of advisor? The advisory role helps achieve an important pedagogical goal because it focuses attention on the reasons for making a specific decision and less on the decision itself. The goal of EBA applications is to help learners learn to consider alternatives and to use appropriate evidence to support their arguments. Because the learner knows her advice will be followed only if her evidence is strong, EBA emphasizes the evidence rather than the conclusions themselves. EBA would therefore be inappropriate for domains in which making correct decisions is the focus.

While the role the learner plays is important, the activities that the learner engages in while using a learning environment ultimately determine its success. In EBA, the task of completing the report is crucial. In designing EBA, we had to face the same tradeoff that all computer-based learning environments face, namely, the tradeoff between understanding what the user is doing and allowing an open-ended interaction. In terms of the reporting task this is a tradeoff between how well the system understands the report and how much flexibility the learner has in creating it. We chooses to partially understand the report so the system can guide and critique the learner's work while, at the same time, provide enough flexibility so that the learner does not feel terribly constrained. There are several techniques we use to achieve this balance, which are described in [Korcuska, Kass & Jona, forthcoming].

A third important aspect of the architecture are the opinionated advisors. Each advisor has different opinions about what the best solution is, can support those opinions with evidence from the database, and can critique the opinions of the other experts and the learner. These are important features of EBA—learners need to be confronted with conflicting evidence. When the learner asks experts for opinions, each one will return different information from the database. In addition, advisor can critique the learner's report and offer advice about how to improve it. Because each expert has a different set of critiques almost any opinion the learner adds to the report is subject to critique. This means that learners can't succeed simply by finding opinions that no expert disagrees with. They must instead concentrate on ensuring that good support is provided for whatever opinions they included in the report.
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Simulation in the Learning of Automated Systems

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At the request and with the collaboration of the Education Ministry of Quebec, we developed an "Introduction to the Technology of Automated Systems" module included in a mandatory high school course, "Introduction to Technology.", using the software Andros that I developed. The 5-year implementation in all secondary schools (14-15 years-old students) of Quebec began in 1993. In 1995 the program was implemented in 125 schools. The challenge was to present, without prerequisites, non-trivial concepts of automated systems that would be understood by every student and every teacher. We have presented the results of this research in [LaPalme 1995].

The learning of automated systems using a table-top automated systems that can be controlled by students, represents certain advantages: it gives the student the opportunity to resolve "systemic" problems, to explore mechanics, electricity and "engineering" concepts. However, as we discover, the learning of automated systems, and especially the control of those systems, deals also with logic, structured problem solving and qualitative time-related concepts. We discover also that when students are given the chance to build the control sequences "in learning mode" or in "programming mode", in "simulation mode" or in "robotic mode", their choice depends of the actual robotics problem they have to solve.

I developed a dynamic representation on the screen of a miniature table-top recycling plant which in turn, represents an actual recycling plant. Hence, the student can develop a good mental representation of the elements he is manipulating on the screen.

Many related concepts intervene in this simulation: the direct and deferred control on the actuators of the system, the direct and implicit control on the pellets, the change of state of inputs controlled by the operator, the change of state of inputs due to movements of actuators or pellets, the direct and implicit change instate of the control system itself, and the different modes of operation. These concepts are integrated into a single screen, permitting the student to visualize at a glance the relations between these concepts. In designing this screen, we kept in mind these principles: the simulation must not give more or less clues than the real situation, but the system must give a feedback for each action of the user.

Like in real life, the system may be in many different modes: it may be in a suspended mode or not, in parallel mode or in sequential mode, in robotics mode or in simulation mode, and in learning mode or in execution mode. These mode are controlled by the icons in the top row of the screen, and all of them except the learning mode can be included in a control sequence.

This simulation give us the opportunity to experiment on time-related problem solving: some movements are best controlled by sensors and there is some process were time is the essence. However time enters in robotics in amore structured way when dealing with parallel movements. In this simulation we use essentially two "rendez-vous" structures: the waiting structure and the interruption structure.

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Computer-Mediated Discussion in a Postgraduate Course: Some Observations

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A full year postgraduate course entitled computer-mediated communication and education was introduced at a New Zealand university in 1994. Six computer conferences (each lasted for two weeks) were incorporated as a component of this course. Eight students and two instructors participated in the online discussion. All the messages posted to the conferences were recorded and analysed and six classroom interactions were observed. Some of the findings are briefly reported in this paper.

Patterns of Discussion

Students participated more equally in the computer conferences, as compared to classroom interactions. There was a clear shift of control from the teacher to the students. As students were encouraged to initiate their own questions and branch out to related topics, quite often, several discussion strands developed simultaneously. Students had to reply to postings promptly in order to follow the flow of the discussion. Thoughtful responses were required. Those students who were not able to access their mail regularly became passive participants.

Any Impact on Class Dynamics?

This medium of communication was useful in helping students to know each other better. Also, as the majority of the students used computers available in the departmental computer lab for communication, they came to meet each other in an informal setting. The online conferences helped provide students with a focus and foster a sense of community. As a result they felt that they were more prepared to engage in collaborative tasks.

However, the computer conferences had little impact on subsequent face-to-face discussions. Students who were quiet in class, prior to the conferences, remained quiet afterwards. It was also noted that those who were more vocal in class contributed proportionally more postings to the computer conferences.

How Did They Like It?

Although students responded positively to computer conferencing and they did enjoy using it, they viewed computer-mediated discussion as something complementary to face-to-face interaction. They did not support the idea of having this course offered totally online. Students considered computer conferencing as time consuming. As a result of time constraint, more than 70% of the students often composed their responses at the keyboard immediately after they had read a posting. The lack of time discouraged them from spending more time on reflective thinking, as supported by this new medium of communication.

Some Other Observations

- There was no correlation between keyboarding skills of the participants and the number of messages posted to the conferences.
- Topics which were challenging and controversial in nature (e.g. one of the topics was 'Is technology neutral?') were discussed enthusiastically at the conferences.
- The role of the moderator was very important in guiding and directing the flow of discussion.
- Students in this course were required to participate in the conferences. This might have affected their rate of participation.
- As the participants all knew each other and they did not wish to be seen as impolite, no 'flame war' was found in the exchanges.
Interactive Distance Learning Networks (IDLN) link complex telecommunications and computer equipment together to provide educators and trainers with the ability to communicate their material live, in an interactive environment. If IDLN programs are to have a significant impact on learning, then organizations are advised to perform an up-front assessment prior to concentrating on the technology. The assessment will answer critical questions, reaching beyond technology, that determine the success or failure of IDLN in an organization. By employing the following model [see Figure 1], organizations are able to logically and systematically work through the decision making process employed when creating an IDLN.

![Figure 1: IDLN Decision Model](image)

The first step in a training assessment is to define the goals or purpose of the training organization or program. By identifying training goals, a foundation is established that provides a means for selecting and reviewing the processes and tools necessary to meet those goals. Goals also provide a means for measuring the success of an organization.

The second step in the model is to identify the training programs that meet an organization's goals. Organizations should be aware of the format of each course in a training program since this information impacts how the material will be used (or enhanced) when communicating by way of IDLN.

The third step in the model identifies the markets impacted by the training goals. Organizations need to understand the demographics of the markets to which they are providing training. This information is critical when deciding the types of technology installed to communicate the training program.

The information gathered and clarified during the first three steps becomes the cornerstone on which organizations make the decision in step four. Step four is the process of identifying the technology that will connect an organization to its market thus enabling organizations to meet their training goals. At this point organizations should be able to meet with technical experts and logically discuss which IDLN architecture would best meet their current and future training needs.

Do not forget step five once the IDLN network is implemented. Technology is developing at such a rapid pace, it is an organization’s responsibility to continue to educate themselves on the best practices employed in the IDLN world.

The decisions organizations make when selecting the technology needed to build an IDLN can first appear overwhelming. However, when the model presented in this document is employed, the decision making process becomes systematic in nature. After the training program is up and running, incorporating continuous improvement methodologies will ensure that the markets continue to effectively receive the training they need.
Teaching Hypermedia Use More Effectively using Mental Models

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Multimedia and hypermedia resources offer a wealth of information not easily accessible as easily before. The amount of stored information is vast, and growing daily. However, locating the stored information may not be easy.

Although they mimic trips to the library, shelf-browsing and literature searching, programs which locate information hopefully make the process easier for the user - if they can use the tools efficiently. If users cannot use search tools efficiently, the potential of available information is lost. The situation can be even more frustrating if we know information exists but cannot locate it.

Each user has a mental model which explains how the computer and a specific program works. This mental model directs all interaction with the computer. If the model matches the way the program operates, all is well. If there is a discrepancy between the user's mental model and the manner in which the program operates, success is unlikely.

The purpose of this paper is to describe the concept of the mental model and its impact on the user's interaction pattern with hypermedia. It also reports a pilot study which will focus on sixteen grade-eight students enrolled in an enriched English course in a French school outside Montreal. They have varying levels of computer literacy. Some have never used them while others are computer game buffs. Some have machines at home, some do not. The students will be assigned an information search task. Before beginning the search, they will be asked how they plan to conduct it. The results will provide the elementary features of their information search models. As the student conducts the search on the computer, their behaviour will be closely observed and documented. They will be encouraged to make their thinking process external by talking about what and why they are doing as they perform each step in the search process. Once the results are obtained the authors will examine the program used to see whether the student made the most efficient tools and strategy to achieve the goal. The results will also provide detailed information about problems experienced by students. We especially want to locate points in which the program prevented a student from using a desired strategy.
The LEAP intelligent tutor trains U S WEST’s customer service representatives using role-play exercises with simulated customers and databases. LEAP selects and modifies exercises to provide trainees with Focused Practice on a small set of rules that varies as trainee learn. LEAP was evaluated using quasi-experimental techniques in a field setting in order to demonstrate to LEAP’s customers (trainees, instructors, and managers) that ITS technology was desirable, useful, and viable.

This page presents the results of two instructional value questions. The first question pertains to trainees’ confidence in their ability to perform the actual task. LEAP was a real confidence builder. At the end of the day of using LEAP, trainees were very confident they could do a genuine Change Order task (Figure 1). The second question pertains to the perceived instructional value of the Recommend function, one of LEAP’s key design features. When a trainee clicks the Recommend button, LEAP recommends a topic, exercise, and study method for the trainee to pursue next. Trainees may accept, modify, or ignore the recommendation. LEAP makes intelligent tutoring decisions but does not force its decisions on trainees. Trainees were of two camps with respect to the Recommend function (Figure 2). Trainees found Recommend rather useful for learning if they wanted LEAP to make instructional decisions for them, otherwise they ignored it. This dichotomous reaction illustrates that trainees have different learning styles and that tutors need flexible instructional approaches to address them.

Trainees enjoyed using LEAP, found it easy to use, and were confident of their newly acquired skills. They believed the exercises were realistic, their student models correct, and they found the instructional recommendations useful. The twenty-nine trainees acquired domain expertise at widely varying rates, mastering, on average, one quarter of LEAP’s content in a one-day classroom-based experimental session. Based on the information provided by this evaluation, LEAP II was funded and fielded.
Recent availability of real time digital video compression technologies hold promise to re-define the format of clinical teaching materials in the field of medicine. Of particular interest are cardiology digital video libraries. Typical cardiology data consists of a rich spectrum of media including motion pictures, still images, sound, graphics (ECG) and paper based documents. Traditional relational databases have severe limitations in accommodation of hypermedia objects due to object categorization and indexing restrictions. The acceptability of large digital cine' databases by medical community depends on the access speed and the accuracy of locating a desired cine' clip. We describe a novel approach to study hypermedia cardiology databases by using Hyper-G as a distributed object oriented database coupled with navigational tools through compressed cine' sequences of cardiac data prior to decompression.

Previous Approaches

Past research concentrated on breaking a long cine' strip into physiologically relevant short clips, annotation and storage in a relational database. An annotation content based query was used to access a desired cine' clip. These methods had obvious disadvantage of being very time consuming and not very accurate. In addition a laborious process of editing digital cine' was impossible to implement in an every day clinical practice which led to difficulties with creation of teaching cardiology databases with a significant cine' component.

Present Approach

Raw digital echocardiographs are stored as a sequence of collections in a Hyper-G database. We used the information already encoded during the compression process prior to decompression to access video frame data and ECG or blood pressure timing to access the temporal location in a long cine'. This has the advantage of not having a computational overhead associated with decompression of every video frame in a sequence. Only a small number of frames is selected for further processing or for browsing prior to decompression. Also, because the coefficients in frequency domain are closely related to the spatial domain, they may be used in detecting changes in a video sequence. As a result of DCT coefficient processing we are able to determine several parameters which effect the performance of a video frame content detection procedure. These include number of blocks that are used in the calculations, number of blocks which form a region and number of regions which form the spatial content. Also a temporal domain resolution must be considered as an additional variable. The procedure outlined above was tested on full motion color echocardiography cine' strips using both MPEG and JPEG standards. All significant changes in echocardiographic data (pulse wave Doppler, 2-D, M-mode) were accurately detected thus significantly reducing the number of pixels that need to be processed, translating into more efficient processing of digital cine'. Modality and echocardiography view specific video frames were discriminated using Digital Cosine Transform (DCT) coefficients in Motion Picture Expert Group (MPEG) and Joint Photographic Expert Group (JPEG) compressed video sequences. In addition, by processing physiological
signal data synchronized with video, temporal regions of interest in cine’ sequences were quickly isolated prior to decompression. The described above technique will used in a digital echocardiography cine’ browser which will provide rapid access to selected video clips in a very large cardiology video database.

References

An Approach to Implementing Adaptive Hypermedia for an Intelligent Tutoring System on the World-Wide Web

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1 Introduction

To provide adaptive hypermedia on the WWW, the integration of the conventional intelligent tutoring system, or ITS, and WWW technologies is being investigated [Kay & Kummerfeld][Schwarz et al., 1996] [Nakabayashi et al., 1995]. However, this type of system requires a special HTML file for the courseware to generate the hypertext needed to achieve individual adaptivity; a standard HTML file is not suitable. This is a serious disadvantage because a huge amount of resources are available in standard HTML files. We have developed the extended Computer Aided Learning and Authoring environment for Tele-education (CALAT [Nakabayashi et al., 1995]) architecture which enables Internet resources to be used as courseware components. In this architecture, a newly developed Material Server (MS) receives queries from ITS and provides standard HTML files adapted to the individual students.

2 System Overview

CALAT is a distributed education system; it has a WWW server integrated with the CAIRNEY [Fukuhara & Kiyama, 1993] tutoring system. CAIRNEY provides the capability to select the most suitable page in the coursewares for each student. In our new CALAT architecture, MS is set between the CAIRNEY process and the httpd; it works like a filter. It (1) receives a query from the httpd or CAIRNEY process, (2) forwards the query to the WWW server containing the data, (3) receives the data from the server, (4) modifies the data for the particular student, and (5) sends the data to the student.

3 Function of MS

To enable adaptive hyperspace support, we have incorporated two modification functions into MS. One is simply adding the CALAT server identification to the anchors containing a static link to non-CALAT WWW servers. It enables clients to send all queries to the CALAT server, so that students are always controlled by CALAT. The other is adding anchors that point to other documents explaining the meaning of a word in a way suitable for the student. Using these functions, students are able to browse HTML resources distributed over the Internet, these resources are adapted to the individual learning status.

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Assessing Educational Multimedia Courseware

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In recent years Cardiff University has become increasingly active in developing a variety of applications on the World Wide Web. It has enjoyed a high profile in this area. One of the major activities has been in producing courseware to support lecture courses for a variety of Computer Science disciplines including C programming, X Windows, Parallel Computing, Computer Vision, Image Processing and Computer Graphics. Some of this work has been supported by the HEFCE funded Teaching and Learning Technology Programme.

During this time various studies on the effectiveness of the courseware as a learning tool have been performed. Also student opinion has been closely monitored. The major aim of this paper is to provide an analysis of our findings from such studies, highlight the lessons learned so far and provide pointers to future developments.

From the experience gained from using a variety of browsers and the WWW to develop a variety of courses in a number of situations we have discovered the following:

- The courseware packages were easy to develop.
- Students find the packages easy and intuitive to use, in particular:
  - They can work at their own pace.
  - The environment allows a two-way learning process.
- The courseware is very popular with students and increasingly to a wider audience over the WWW.
- The courseware are easily extensible and updatable. Material from the whole WWW can be easily integrated. The ability to use Unix (and other) scripts and more significantly to run (Java) programs directly means that little is not achievable with careful thought and planning.
- Our courseware has been recognised as a beneficial aid to learning.
- Our department has benefitted from a reduction in manpower resources in support of this and other courses available in hypertext form.
- Courses can be developed to suit a wide range of disciplines and abilities.

To sum up, we feel that global hypertext-based on-line courseware provides great flexibility for future educational needs and we have extended global resources in this area.

References


The Work Expansion and Implementation of Multimedia Authoring Tool "TSUMIKI" Generating Webpage, Visual Editor & OLE support

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1. Introduction

Most teachers of primary and junior high school in Japan are not familiar with computer literacy. Because they have never been educated on Computer Science during they were students.

In order to help them, we have developed the multimedia authoring tool called TSUMIKI. The TSUMIKI, which doesn't only offer to users intuitive simple operation but also requires any program work. The fundamental idea of TSUMIKI is based on a Japanese traditional amusement "KAMISHIBAI" for children. KAMISHIBAI is to present a story using paper pictures with narration, just like a slide show by story tellers. [1] The revised TSUMIKI can automatically convert titles created by TSUMIKI to Web pages and convert file format by choosing the function through pull down menu. Furthermore we have developed a editor for authoring tool. The editor enable us to delete/append items on the TSUMIKI-page and to exchange TSUMIKI-page among the title and to edit the objects which come up on a TSUMIKI-page using mouse operation.

2. Converting TSUMIKI script file to html

After making a title, TSUMIKI generates a script file to replay. Script is a program made by TSUMIKI commands. The commands are then filtered into its HTML tag. The argument means the path address of the file being pasted. Then file format is converted from the bit map file to GIF and is located at desired directory. By doing this, the main body of the HTML and its image files are generated.

3. Visual Editor

Through developing a editor of TSUMIKI, we propose a new concept for Multimedia Authoring Tool. The editor of TSUMIKI consists of two parts, editing a page and page supervisor. In editing a page we can paste and delete objects on the page. When we paste a object on a page, there are two ways. One of them is to choose a necessary object from menu or tool bar. The other one is to drag&drop it from file window. For pasted objects, their icon appear on the right side of the page, which is called the sequence window of the pasted objects. If you want to alter the sequence of the pasted materials, you can change it by dragging a desired object, and dropping it before or later in the sequence. For creating a new page, you choose "New page" in the menu or tool bar and you configure a numerical page number. Then editor responds with a quite empty page formation and the sequence window of the pasted objects is initialized. This new page is appended as the last one in the title.

4. Conclusion

We proposed a multimedia authoring tool which can automatically create WebPage and has Visual editor. Those idea was realized as expansion of TSUMIKI. And also TSUMIKI supports OLE.

A Comparison of the Influence of CD-ROM Interactive Storybooks and Traditional Print Storybooks on Reading Comprehension and Attitude

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CD-ROM interactive storybooks capture students’ attention and stimulate their imagination. These books combine text and graphics with sounds, narration, and animation. These changes in text presentation have the potential to influence students’ reading comprehension and attitude. Therefore, this research was designed to compare the reading comprehension and attitude toward reading of third grade students who read CD-ROM interactive storybooks with students who read traditional print storybooks.

The participants were two groups of third grade students randomly chosen from nine classes at an elementary school in an urban area of the southwest. Prior to the study, students were given the Metropolitan Achievement Test, Seventh Edition (MAT7), Primary 2, Reading Comprehension Subtest and the Elementary Reading Attitude Survey. Students were matched on the basis of gender and reading comprehension scores from the MAT7. One student in each pair was randomly assigned to either the experimental group or the control group. Students in the experimental group read CD-ROM books on the computer and students in the control group read the same books in a traditional print format. The following three stories were used in this study: Mud Puddle from Discis Books, Arthur’s Teacher Trouble from Living Books, and Arthur’s Birthday from Living Books. Students worked with the researcher in groups of approximately four students. Before reading, the students participated in a discussion to activate their prior knowledge and establish questions to answer during reading. After reading, the students participated in a discussion of the story and answered the questions generated in the prereading discussion. Their comprehension was assessed with open-ended questions and by story retellings. At the end of the study the Elementary Reading Attitude Survey was administered as a posttest.

The scores on the open-ended questions and the story retellings were analyzed using a t-test for paired samples. The results of the t-test indicated there was no statistically significant difference between the reading comprehension of the students who read the CD-ROM storybooks and the reading comprehension of the students who read the traditional print storybooks as measured by open-ended questions. The t-test for paired samples yielded a t of 1.87 which was not statistically significant (p=.070). However, there was a statistically significant difference between the groups as measured by story retelling. The t-test for paired samples yielded a t of 2.12 which was statistically significant (p=.041). The attitudinal data collected were analyzed using an analysis of covariance. The results of this analysis indicated there was no statistically significant difference between the reading attitude of the students in the experimental and control groups. The analysis yielded an F ratio of 0.01 which was not statistically significant (p=.928) and, consequently indicated that the adjusted score for the experimental group (adjusted mean = 59.43) was not statistically significantly higher than the adjusted mean for the control group (adjusted mean = 59.28).

The results of this study indicate that CD-ROM storybooks may have the potential to increase students’ reading comprehension. Additional research needs to be undertaken with more participants and a greater number of CD-ROM storybooks.

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The World Wide Web is a chrysalis technology; in transition between its origins and an unknown future. The rate of change in. But it is essential that education and educators not fall behind. The web has always been able to deliver multimedia. Movies and audio could be delivered to be played through a separate player application. This has changed with the introduction of streaming audio and video plug ins. When a page is accessed the server starts to load the first few frames of the video or audio to the client. Once these are loaded they begin to play. While they are playing on the client, the server loads the next few frames. So while the client is playing the few frames that it has the server is constantly loading the next frames. With this technology it is possible to load hours of audio or video with what appears to the user as only a few seconds of initial delay. One the clip starts there is no noticeable delay. There are currently two main providers of streaming audio technology; RealAudio from Progressive Networks, and ToolVox from VoxWare. The disadvantage of current applications of streaming audio is that they produce very low fidelity at modem bandwidths. Streaming video is an even newer technology. VDOlive by VDONET was one of the first to market this type of tool. Streaming video applications share many of the disadvantages of the streaming audio players, though eventual increases in bandwidth available to learners and improvements in compression algorithms are likely to solve many of these problems.

In the past, interaction in web pages was provided by the text links, CGI scripts, and the clickable graphics. Today Shockwave for Director, by Macromedia; and Java, by Sun Microsystems allow a much greater range of interactivity and of designer control. Java is a programming language which supports programming for the Internet in the form of platform-independent Java applets. These applets are small programs that are downloaded to the learner’s computer. They interact with the learner’s web browser, enabling it to perform tasks it could not with HTML alone. Java applets can be used to produce animations, graphics, and sounds; to collect and manipulate data; and to control the web browser itself. Shockwave is similar to Java in that it loads discrete applications onto the learner’s computer from within a web page. These applications are originally created in Director. They can be graphics, sounds, animations, or anything else that can be created in Director. Shockwave applications can also be used to control the learner’s browser and to collect and manipulate data. There are two basic differences between Java and Shockwave. Creating applets in Java requires a fair bit of programming skill for the designer. Shockwave applications, on the other hand, are created using Director which may require the use of Lingo; though many animations can be created with no coding involved. Most Java applets are very small and load invisibly to a Java aware browser. Shockwave applications can be quit large and often take several minutes to load at modem speeds.

Traditionally the World Wide Web has been a strictly 2D world. The recent introduction of the Virtual Reality Modeling Language (VRML) has changed that. VRML allows learners to access three dimensional creations through their web browser. There are two basic types of VRML entities: objects which can be manipulated and environments which can be explored. VRML, like HTML (HyperText Markup Language), is a standard rather than a specific program. There are several browsers and plugins which allow learners to access VRML documents. Apple’s QuickTime VR technology, which allows designers to create walkthrough models of real places, and manipulatable models of real objects, is currently available on the Web through the use of an external viewer, but they are scheduled to release a plugin for Netscape in the spring of 1996.

What do all of these new developments mean to educators and designers? Each technology has its unique uses. Streaming audio and video allow for real time, real media usage which can increase both affective and psychomotor learning. They also allow the study of domains which require access to significant amounts of real media, such as music. Data control and manipulation enhances the creation of web based tests and allows for complex mathematical equations and instruction. Immersive simulations in VRML allow for more realistic visualizations. With the ever increasing rate of change of technology, it is a daunting task for anyone to keep up with what is happening on the Web. But it is important that we as educators do not fall behind, otherwise we miss out on all the opportunities these changes bring us.
This article proposes a way for user friendly navigation, orientation, and interaction with virtual learning environments. Our operational and practical approach is to exploit the characteristics of desktop VR systems, mainly the first person user viewpoint that allows complete movement at will in real time, and the ability to manipulate the virtual environments by physical actions and/or change in real time. The final purpose is to “hide” the computer, building an “invisible” interface for the communication with virtual worlds in educational applications.

The work considers Human Computer Interaction as a matter of sensory ergonomics, where computers are assumed as perceptual, rather than conceptual, tools, and they are primarily sensory transducers and not “cognitive” artifacts [Waterworth 95]. We believe that we can allow students to experience more using computer tools, and especially virtual reality, which could be viewed as enhanced reality.

We propose the virtual hand for navigation and orientation in virtual environments, and a simple system for tactile feedback for proximity and manipulation of virtual objects.

In general and especially in educational applications, there is little research on presence, orientation and manipulation in 3D virtual environments, as well as on input/output devices.

Virtual Reality and virtual learning environments have been proposed for classroom use. Common input navigation interfaces are the joystick, the 3D space mouse, and the spaceball, and output ones the screen, video walls, and head mounted displays. Assuming the data glove provides tactile feedback, it is an input/output device.

The disadvantage of these devices (except for the dataglove with tactile feedback) is that the virtual guidance they offer to the user is the icon of the mouse, or a rectangle indicating the location in the virtual space. This causes orientation problems with the students being lost in the virtual environment, and not knowing where to move in order to achieve their goal. Moreover, these devices do not give a direct response to the user on how to interact and manipulate the virtual objects. That way, students do not know if they have approached a virtual door they have to open, or if they have clicked a picture to see what is hiding behind.

We have designed a virtual hand that is the representation of the user’s hand in the virtual world for his/her navigation and interaction processes. The user sees at any time his/her hand in the world pointing at the direction he/she moves. Thus, the user knows exactly where he/she is in the virtual environment and how the virtual hand has to be directed in order to go where he/she wants.

The virtual hand is a 3D hand and operates as a real one. It can open and close, move its fingers independently, and point at an object. The virtual hand operates using any kind of 3D input device, and moves its fingers using the keys of the device (e.g., spaceball or spacemouse). Of course, there is some research on virtual hands, but these are either 2D icons, or lose their “natural” shape when operate. We have paid attention so our virtual hand to be natural in all its operations.

Knowing that tactile feedback for motor responses maintains stimulus-response compatibility and should be encouraged whenever its integration into the human-machine interface is possible [Akamatsu et al. 95], we have introduced a simple tactile feedback system connected to our virtual hand. This uses a shape memory alloy (SMA) actuator that outputs electric pulses of a given amplitude and repetition rate when the user interacts with a virtual object. Our system uses just one SMA wire giving the sense of proximity and touch. In virtual worlds, there is a confusion concerning the approach of an object (door) and the interaction with it (opening the door).
With our system, the user gets a signal— a sensation of touch to his/her hand, knowing when he/she has touched a virtual object and can interact with it.

Our first results of a case study with personnel of the lab, show that they have the feeling of presence and interaction in the virtual room in a more natural way than that with the use of the standard input devices.

References


Mediated Design: A Collaborative Learning Experience

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Mediated Collaborative Design

There is a great interest in the related fields of computer-supported collaborative learning (CSCL), computer-supported collaborative work (CSCW) and computer-mediated communication (CMC). The Internet can support mediated design while providing a collaborative learning environment. Using a Type I developmental research approach, we studied the group dynamics of learning and design, as members of the Internet Task Force at the University of Colorado at Denver collaboratively developed a home page on the World Wide Web for the School of Education.

Cognitive Processing Model

Group dynamics within a learning community has been studied using many approaches, including progressive discourse [Bereiter 1994] and communities of learners [Brown 1994]. Brown's concept has been extended to include computer-supported collaborative learning [Scardamalia & Bereiter 1994; Hanson & Gladfelter 1995; Crook 1994; and Yakimovicz & Murphy 1995]. In our research, a cognitive processing model emerged from our collaborative design efforts. Our design process built upon progressive discourse and supported transformative communication among participants [Pea 1994] as knowledge was restructured. Our design project involved four interrelated processes which provide a framework for successful collaboration. Our cognitive processing model includes [Sherry & Myers 1996]:

• metacognition—conscious reflection and monitoring of our own cognitive states and processes,
• knowledge development—building a relevant, common base of knowledge, experiences, and associated skills,
• authentic task—identifying and taking ownership with the cognitive demands of the design environment for which we are preparing ourselves, and
• research—questions concerning the design process and our group dynamics that emerged as a result of working on our task, and that could be dealt with experimentally.

Literature References


Effects of Navigation Structure in Multimedia CD-ROM Courseware on Learning Achievement

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Introduction

Two common ways of organising information on a CD-ROM are a linear and network structure. In a linear format, a user is led through the material in a step-by-step fashion. In the network format, learners are allowed greater control and choice of the manner in which they may proceed or navigate through the program. This study investigated:

1. Effects of the two different navigation structures in CD-ROM courseware (linear and network) on students’ knowledge of content (about dinosaurs and prehistoric animals) after a brief exposure (twenty minutes) to CD-ROM courseware.

2. Influence of gender and level of students’ experience in the use of CD-ROMs on their knowledge of the content after exposure to a linear and network navigation structure.

The research questions pursued in this study were as follows:

1. Do particular navigation structures in CD-ROM courseware influence cognitive learning outcomes differently?

2. Is there any relationship between experience in the use of CD-ROMs, as well as gender, on achievement from different navigation structure?

Method

Subjects in the study were seventy students in the third-grade at a large metropolitan Primary School in Queensland, Australia. These students came from mainly Caucasian, middle to low socio-economic status families. They were divided into two groups on the basis of their prior experience in the use of CD-ROMs and then randomly assigned to one of the two programs with equal numbers of males and females and those with and without experience in each group. The independent variables in this study were:

- CD-ROM programs with different navigation structures
  - Linear navigation structure;
  - Network navigation structure.

- Prior experience in the use of CD-ROMs (with and without experience).

The achievement tests were designed to measure students’ knowledge of dinosaurs and prehistoric animals. Students engagement in the CD-ROM program was operationalised in terms of the time they stayed on/off task over a ten minute period. Two commercially produced CD-ROMs were selected for the purposes of this study. These were: (a) Dinosaur Discovery (linear navigation structure), and (b) Microsoft Dinosaurs (network navigation structure). The two CD-ROM programs were selected for the high level of compatibility in the coverage of information on dinosaurs and prehistoric animals, reading level, screen design, searching capabilities and help function. Each learner was given twenty minutes on the CD-ROM to find as much information as they could on dinosaurs and prehistoric animals. After twenty minutes subjects were administered the achievement post-test individually. Two weeks later they were administered the same achievement post-test in a small group setting.

Results
Results of the study showed that third grade students after twenty minutes of exposure to the two CD-ROM programs showed a significant increase in their specific(detailed) knowledge of dinosaurs and prehistoric animals, $F(1, 68) = p < .02$. Subjects’ gender and level of experience in the use of CD-ROMs were also found to have a significant effect on their achievement from the CD-ROM programs. Male third grade students without any experience in the use of CD-ROMs outperformed their counterparts with CD-ROM experience on the achievement tests. The reverse was true for female third graders. Females with experience in the use of CD-ROMs outperformed their counterparts without CD-ROM experience on the achievement post-tests.
Electronic Performance Support System (EPSS)

An electronic performance support system (EPSS) is customized software that integrates information, tools, and procedures to help users as they actually perform a task. A typical performance support system provides a combination of the following capabilities:

- Just-in-time, task-specific information such as step-by-step procedures
- Reference information, such as machine specifications, for a job task
- Expert advice about a job task
- Automated tools to help the user perform tasks.

Origami EPSS

Our team created a simple multimedia EPSS to teach users how to fold a Japanese paper jumping frog. The media we used included text, drawings, audio narration, and videos. To free the user’s hands while folding the paper, we provided a voice recognition interface to the EPSS.

We organized the information into sections that provided the step-by-step procedure for folding the paper jumping frog, assistance with correcting problems, and background information on origami.

Lessons Learned

We estimate that it took 150 labor hours to build our origami EPSS. We used 15 different software packages, 13 significant hardware items, and skills that included computer programming, graphics design, hardware maintenance, user interface design, and writing. Along the way, we learned several lessons. They were:

- Use an interdisciplinary design team—Our team included educational technologists, a graphic designer, training experts, and a user interface designer
- Plan for development to take a lot longer than you expected--We found that it often took 10 times longer to accomplish a specific development step than we expected
- Iterate. Iterate. Iterate--We found that it was very worthwhile to frequently perform a series of short develop-test-fix steps
- Know when to stop--Limit yourself to making changes that obviously help users perform their tasks.

To see a full version of this paper, go to page http://mime1.marc.gatech.edu/imb/people/larry.html on the World Wide Web. For additional related information, see the paper by Ockerman, Najjar, Thompson, Treanor, and Atkinson in these proceedings.
As other studies have demonstrated, students in the domain of business cost accounting often fail to build a coherent knowledge base, instead they learn a set of some concepts (fixed costs, variable costs etc.) and more or less separated rules and principles how to calculate prices. The basic idea was therefore to have students to solve case studies, using a computer based learning environment: to let them calculate completely the price of an industrial good by themselves, in a rather authentic environment equipped with all necessary tools and help facilities. Defining subtasks, seeking for relevant data and planning the calculation process, should promote the construction of a stable and consistent structural knowledge. Research and development followed what we call an "evolution strategy": Any specific new help or advice facilities was tested in a control group design (two versions of the program), if it made a positive effect it became an integrated part of the program also for further studies.

The screen displays a virtual office with tools and resources (e.g calculator, notebook, files with data and forms on a bookshelf). There are several local and global helps in any version, including two comprehensive hypertext books on business cost accounting and on learning (e.g. learning strategies, learning techniques, motivation). To do the job, the learner has to find applicable data in a file, to compute values, to fill them into forms of another file, to compute parts, to sum up etc. until the price is calculated. Fulfilling completely one such task takes four to six hours. Up to now five case studies had been developped following this structure. We did two kinds of studies: (a) Quasi-experimental studies to explore the effects of specific help facilities and (b) single case studies with thinking aloud and video confrontation (interview with the learner, confronting him/her with video records of his/her work).

In a first study we investigated the effects of a demonstration ("modelling") of the calculation process to be learned. The independent variables were operationalized by two variants of the learning environment. Version 1 contained a presentation of one possible way of problem solving of about forty minutes. It was obligatory for the learners of the experimental group and could not be stopped. The control group, variant 2, had no "modelling" element; all other help functions were available for both the groups. Dependent variables were failures made in the course of solving the calculation problem, the navigational behavior of the learners, the time needed for problem solving, as well as the answers to questionnaires concerning experienced difficulties and the assessment of learning success. Furthermore some relevant personality variables were assessed (e.g. self-efficacy). Subjects were 20 apprentices of business administration (6 male; age between 18 and 25 years). Each 10 persons worked on one of the both variants. All subjects solved the calculational task correctly. The clearest effect of "modelling" was the accelerated speed in working on the task, but this gain of time is equalized by the duration of "modelling".

The subsequent field studies were similar to the first one. We investigated effects of the following help facilities: A dynamic graphical representation of the structure of the calculation process ("map"), which can also be used for navigation (two studies), a facility for learners to verbalize what they had learned up to a certain moment (two studies), answering open questions on relationships concerning relevant concepts (one study).

Although all of these helps - according to questionnaire items - were accepted well by students, they were used less than expected. Thinking-aloud studies strengthened the overall-result: Students learned about the structure of cost accounting on the operational level (interdependence of the different calculation steps), they did not build structural knowledge on the conceptual level. Analysing the learning processeses from the perspective of a theory of self-regulated learning [Butler & Winne 1995] we identified at least two reasons for this result: (a) Fulfilling such a complex calculation task leaves not enough cognitive resources to build simultaneously a more abstract conceptual structure. (b) Feedback in our learning environment is only given for steps of calculation, not for advances in the development of a conceptual structure.
So, in the newest study, a “concept-mapping” facility was integrated into the learning environment, having the learners of the experimental group to work out and to represent actively relationships between key concepts of cost accounting before being allowed to start just calculating. This should provide feedback for learning conceptual structures. Another study in preparation will investigate the use of “worked out examples” [Sweller 1994], assuming to facilitate thinking about conceptional relationships through reducing the “cognitive load”.

References


Teaching Social Skills Through Face-to-Face Versus Computerized Instruction

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A meta-analysis of studies comparing computer-assisted instruction (CAI) to conventional instruction showed higher test scores for students participating in CAI courses in 37 out of 54 studies and the difference in attitudes towards the two kinds of courses was small (Kulik, Kulik, & Cohen, 1980; Kulik & Kulik, 1991). Few studies, however, have assessed the efficacy of CAI in teaching social skills.

The present research hypothesizes that CAI instruction will be as effective as face-to-face instruction and that students in both of these groups will increase their social skill competency more than will students in the control group.

This study compares instruction in social skills delivered by interactive CAI with face-to-face small group interaction. In addition, a control group is used in the comparison. The interactive CAI consisted of a multimedia hypercard program developed by the primary author. This program uses a game format to develop the following social skills: (a) reduction in stereotyping (b) valuing diversity, and (c) cross-cultural communication and conflict resolution. The face-to-face instruction teaches social skills through small group structured experiences which are the same as those on the computer program.

Social skills changes are measured by a 25 item social behavior scale developed by the primary author with an internal consistency alpha of .95. This scale assesses cognitive, attitudinal, and behavioral changes in the three social skills.

The design is a nonequivalent group pretest-posttest control-group design. Participants consist of undergraduate students enrolled in upper division psychology courses. The control group (n=37) includes all students enroll in an abnormal personality psychology course. The two treatment groups consist of all students enrolled in two sections of a course in interpersonal and group processes. Students from all courses were equivalent in computer literacy.

A One-Way ANOVA on the differences between the pre and post test scores shows a significant relationship between both instructional interventions and the difference in social behavior score F (2,106) = 0.04, p < 0.05.

The least significant difference (LSD) calculation shows a significance level of 4.31, p < 0.05, with significant differences between the pre and post tests for the CAI and face-to-face groups and no significant difference for the control group. The results of this study support a high level of efficacy for computer-assisted instruction in social skills. CAI was as effective as the face-to-face instruction and significantly more effective than no intervention in increasing social skills.

References

Software Engineering Knowledge Modeling techniques can be adapted to Instructional Design for modeling the content of learning in a useful and integrated way with regards to other instructional design tasks. In the Didactic Engineering Workbench (AGD), the knowledge modeling activity refers to the four knowledge types: concepts, procedures, principles and facts. These knowledge units are linked by six types of links (is composed of, is a kind of, precedes, governs, has for instance, is input to or output of). We have used this set of objects (4 types of knowledge and 6 types of links) to create a graphic editor that allows for the representation of various knowledge domains, whatever their nature or complexity.

**KNOWLEDGE MODELING AND THE DEFINITION OF TRAINING NEEDS AND LEARNING OBJECTIVES:** For each selected knowledge and for each target audience, one determines the actual and the desired states of competency. Target learning competency levels have an important impact on determining the learning objectives level. On the other hand, the discrepancy between the target state and the actual state shows the learning need; the scope of the learning needs could justify further development of the knowledge model.

**KNOWLEDGE MODELING AND THE LEARNING SCENARIOS:** A learning scenario is a network of learning events, didactic instruments and evaluation activities, as proposed to the learners. For example, in a given course scenario, learning units are linked with optional or mandatory precedence links to form a suggested learning path. We simply drag&drop the knowledge units in the learning events in order to organize the content.

**KNOWLEDGE MODELING AND THE DIDACTIC INSTRUMENTS PLANNING:** AGD methodology has labeled five groups of didactic instruments: learner’s manual, teacher’s manual, presentation documents, production instruments, reference instruments which are linked to learning events in a learning scenario. They are also linked to the knowledge units they cover. This allows for the creation of an instruments data base, from which it becomes easy to find/retrieve instruments on a given knowledge. Such a data base facilitates reusability and maintenance of existing didactic instruments.

**Integration of Instructional Design Knowledge**

We will now focus on ID knowledge, which forms the basis of AGD system. We use three of the basic knowledge categories used in the AGD knowledge representation system: conceptual ID knowledge, procedural ID knowledge and strategic ID knowledge.

**CONCEPTUAL KNOWLEDGE AND PRODUCTIONS:** Because we were in the process of building a computer support system, each concept had to be defined very precisely using an object-oriented methodology. These concept definitions gave us the structure of the storage module of AGD system, all the concepts components forming a large graph called « a project ». They were used to build a contextual on-line help system for the subject matter expert unfamiliar with ID terminology.

**PROCEDURAL KNOWLEDGE AND TOOLS:** The concept of a Learning system evolved through the definition of the processes involved. Each higher level process or task in the hierarchy gave birth to a design tools. The lower level tasks down to the individual operations correspond to functionalities within these tools.

**STRATEGIC KNOWLEDGE AND ADVISOR SYSTEM:** This hierarchy of processes helped us identify and classify the strategic ID knowledge useful to the system. To each process, we can assign a strategy, defined as a set of principles that rules, constrains or controls the corresponding task. In this way, to each major process (or tool) in the system, a set of design principles can be associated, thus providing a base for the advisor agents within AGD Advisor System.

**Discussion of the results**

Most of the comments, experimentation results and productions with AGD are quite encouraging on the following issues: usability and productivity, coherence of learning systems, reusability of components in new projects, AGD as a learning support tool in Instructional Engineering. Experimentation results have proven that
the knowledge model is a powerful tool, not only for structuring a knowledge domain, but also as a good communication tool to collect data and validate it with a subject matter expert. Knowledge modeling offers the possibility to structure a knowledge domain without giving immediate attention to instructional processing. It also allows for quick verification of consistency within the knowledge models.

Research achievements

The development of AGD has made possible the achievement of research results on many fronts: a knowledge modeling technique adapted for instructional use has been developed during the project; a method for the design of Performance Support Systems and advisor components has been proven feasible; a way was found to integrate knowledge modeling as a unifying principle to the design of learning systems; some strategic ID knowledge units were defined, integrated and made operational in an Advisor component.

References

As electronically linked, nonlinear text, hypertext has the potential to test aspects of contemporary critical theory, particularly those concerning textuality, narrative, and the roles or functions of reader and writer. With its webs of linked text segments and networks of alternate paths, hypertext constitutes an interactive and polyvocal technology, favoring a plurality of discourses and blurring the boundaries between reader and writer who become collaborators in the mapping and remapping of textual components. Hypertext embodies Derridean deconstruction, Julia Kristeva's notions of intertextuality, Bakhtin's emphasis on multivocality, Foucault's conceptions of networks of power, and Deleuze and Guattari's ideas of rhizomatic, 'nomad' thought [Landow 1994].

Using hypertext in the composition or literature classroom may work against traditional ways of reading and writing. Educational hypertext constitutes neither a simple continuation nor a replacement of current reading and writing theories and activities, but a positive disruption. It may be useful as a measure of the inadequacies of current pedagogy [Johnson-Eilola 1994]. What we have traditionally called the structure of the text is the relationship between an experience of reading determined by the linearity of print and the network of allusions among elements that are separated in the physical space of the book. Hypertextual form is based on the absence of structures that are common in most printed texts. Hypertexts do not mark or set up clear divisions between text and context, the primary text and the footnotes and appendices on the periphery of the book. Hypertext is a useful tool to make a text's relations and connections accessible and incorporate what we usually understand as context.

Poststructuralist theory would argue that textuality is by nature openended and the reading process is never sequential. Readers do not progress from word to word, line to line, page to page until they have finished the text. Rather they perform a text within referential frames and make multiple connections while reading. The stability of traditional texts is both physical and psychological; the physical, stable presence of the text tends to deny the intangible, psychological text the reader attempts to construct. Hypertext includes the same range of internalized responses to a text, but abandons the physical stability of the printed text by adding technologized conventions: Due to the mechanism of links, it is not predominantly the reader's interpretation of the text that changes but the text itself. Even poststructuralist theories cannot fuse the reader and writer in the visible, surface-level manner experienced by hypertext reader-writers. Hypertext "creates an almost embarrassingly literal embodiment" of the theoretical work of poststructuralists such as Roland Barthes and Jacques Derrida [Johnson-Eilola 1994]. Where Roland Barthes' transformation of reader to collaborative writer takes place in the psychic world of the reader, hypertext makes the intertextual, networked text visible and active for the reader-writer [Moulthrop 1989]. Hypertext emphasizes those very qualities--the play of signs, intertextuality, the lack of closure--that deconstruction poses as the ultimate limitations of literature and language.

References


Learning Environments for Manufacturing: a Framework and Example

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Manufacturing by its very nature is a broad multidisciplinary field requiring general knowledge of the entire enterprise including the design, production, and delivery of finished products. The manufacturing engineer requires knowledge from the diverse fields of robotics, materials, CAD/CAM, communication systems, budgeting, management, continuous quality improvement, and training the workforce. Integrating this knowledge is a formidable task requiring a balance of technical depth with a broad understanding of the problems facing industry. Equally important is an understanding of the collaborative team-oriented approach of real-world problem solving. Educating the next generation of manufacturing engineers through traditional educational techniques alone exaggerates many problems and concerns. For manufacturing is ultimately concerned with using real live processes and equipment to create real products. The effective manufacturing engineer must develop a strong conceptual link between what he/she hears in the classroom and what goes on in the real world.

To solve the above problems we have developed a framework for development learning environments (LE) which is based on the constructivist approach to learning. Learning is considered as an active process of building learner's knowledge. The main pedagogical approach is learning by doing and reflecting. We propose a LE which consists of a working environment, a set of problems to solve (assignments), and may include: a means for scaffolding, collaboration, articulation and reflection; reference materials (handbooks, encyclopedia, case libraries etc.); learner's skills/knowledge model; and learner's activity tracing.

The main idea is to create an environment which simulates to some extent the real world and allows the learner to solve the real problems. The learner play a role of an employee who got a job in a firm. He/she "lives" in a virtual environment, has a supervisor and colleagues, and he/she is responsible for solving "real world" problems. He/she has a list of problems to be solved and can choose any problem from the list, but sometimes the supervisor or colleagues can request to solve a problem. To solve a problem he/she can use tools, reference materials, communicate to the virtual or real colleagues. After completing a problem the learner should reflect on the problem domain, and his/her own solving and learning strategies. It must be also an authentic activity, such as creating a summary, preparing the brief report, or indexing the case and reorganizing the index of his/her own case library (portfolio). Summing up the main features of the framework for creating LEs we can say that it deals with an individual-centered environment which simulates a real world environment including its social component, provides support for apprenticeship, scaffolding, and reflection, and uses learner modeling techniques to tailor scaffolding to the current learner's level.

A LE Ergonaut for acquiring the knowledge and skills necessary to conduct ergonomic job analysis and working place redesign has been developed. This LE is designed to engage learners in authentic tasks from the onset. A set of tools and reference sources are provided in a manner similar to what the real world practicing ergonomist encounters. The LE is an open one allowing the learner to explore and experiment with the resources and problems included. However, the goals of the learner are explicitly stated to be finding solutions to real problems and accepting responsibility for the outcomes of his/her actions. The learner is assigned a role on a simulated ergonomics team and must interact with and solicit help from other members of the team in order to solve the problem completely. A selection of problems varying in complexity is provided. Explicit support is provided for the learning activities through scaffolding of the complete analysis/solution procedure, identification of learning needs, and reflective articulation. Throughout the learning process the learner constructs his/her own case library of problems and solutions which serve as the basis for reflecting on what has been learned and for future reference. Progress and actions are monitored to infer the student knowledge state and provide intelligent assistance when requested. Student activity tracking is also included. A final component included in the environment is a set of working tools which support both learning and future job performance; i.e. checklists, worksheets, planning documents, etc.

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An Interactive Environment Based on a Distributed Architecture for an Educative Museum Application

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Theatres or exhibitions, as well as planetariums or museums, have virtually the same goals as multimedia, but they refer to larger audiences. Nowadays they use more and more multisensorial presentations in order to compel more emotion or understanding. This kind of group applications, in contrast to desktop multimedia, requires a strong integration of classical multimedia and a lot of extra equipment such as spotlights, video projectors, motorized mirrors, etc. In order to solve this problem we propose a dedicated distributed architecture allowing to get all the advantages of the new multimedia techniques for this kind of wide interactive environment (especially for museums and planetariums). In this short paper, we focus on the design of a reactive information system which will develop into a real-time interactive area called ENVI [Pinot and Thirion 95]. We lay emphasis on user comfort, especially on the way to interact with the system.

ENVI distributes all the activity of an interactive multimedia system on several micro-computers connected by a hierarchy of networks. Each activity is instantaneously handled by one processor, according to instructions sent by a host processor. Each computer is a specific station of the interactive multimedia presentation, for example a sound station, a video station, etc. This architecture allows the addition of more specific stations controlling physical actuators, just like spot-lights, stepping motors or more general scenery. These theatrical-set effect controllers are built around a powerful hardware called Shownet™ [Schittly and Perrin 88]. This architecture is based on a master module which interacts both with the slave controllers and with a Macintosh host. The slaves adapt the peripheral hardware to the network and run instantiations of generic control tasks. This architecture is under control of a specific software called PlanetShow™ [Thirion 93] which allows for setting-up of the network, definition of show hierarchy, interactive learning of an effect or description of more generic effects based on a scripting language. Stations activity can be completely concurrent and the whole system is remotely controled by a supervisor called “director”.

We have experimented this architecture in the realisation of an interactive area for a scientific museum which has planned some interactive scientific information terminals. The main objective for this interactive environment is to offer an educational function. With ENVI, interaction is not based on a touch screen displaying the technical object to explain but happens directly on the technical object according to user’s behavior. Visitor’s entrance and motion in the reception area is detected (radars, sensors, switches, etc.) and every object manipulation triggers events which start multimedia sequences. With this prototype, we want to introduce the concept of reactive environment. Modelization of user’s behaviour and observation of his actions featuring his point of interest allow to build an attractive reactive multimedia presentation.

In conclusion, we have proposed a new kind of group application which tries to apply multimedia technology to large environments such as museums or theatres. This system was validated on a typical museum application where the innovating principle is: integration of distributed systems for interactive presentation offering a direct and real-time interaction with the object to present.

References

Dimensions of Learning Styles and Their Influence on Performance in Hypermedia Lessons

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Hypermedia permits the tailoring of instruction to meet individual student needs. Adapting instruction to meet individual student needs is one way that instructors can promote instructional effectiveness. The unique characteristics of hypermedia systems permit instructional designers to account for individual differences such as learning styles [Yoon, 1993-94]. However, it is unclear as to what structures promote effective instruction for variations in performance that may be attributed to learning styles.

Hypermedia facilitates the notion of learner control which permits learners to structure learning experiences to account for their individual differences [Jonassen, 1986]. Learner control is the amount of personal responsibility or control an individual can exert in an instructional situation. This control may be exhibited through sequencing.

Learning styles refer to individual preferences toward learning [Davidson, 1990], and specifically concern how individuals perceive and process information. One learning styles theory that is used for adult learners is the Experiential Learning Styles Theory [Smith & Kolb, 1986] which is comprised of two bipolar dimensions: processing (reflective-active) and perception (abstract-concrete).

The variables of learning style and hypermedia instruction have been experimentally combined in a very limited fashion, revealing unclear results [Cordell, 1991]. These results tend to suggest, however, that learning styles may influence student performance when learning with hypermedia. This study was designed to explore what influences the components of learning style (perception and process) had on student performance in three different hypermedia environments.

Preservice teachers (n=137) in an Instructional Technology class in a southeastern university completed a learning style inventory and were randomly assigned to one of three hypermedia treatments (hierarchy, hierarchy-with association, and web) which reflected low, moderate, and high levels of learner control. At the end of the treatment, subjects completed an immediate posttest.

There was a significant interaction between the processing component of learning style (reflective-active) and treatment (F(2,120)=4.27, p<.05). In the hierarchy treatment, performance increased as subjects became more reflective. The main effect of perception on performance was significant (F(1,120)=4.80, p>.05). As subject abstractness increased, so did scores for all treatments.

Maximizing student performance through individualization is one goal of using hypermedia for learning. Instructors should ensure that instructional hypermedia take advantage of the influences of individual differences such as learning styles. Including support for varied learning styles can ensure that all students can learn effectively in a hypermedia system.

References
A Systems Approach to Adaptive Computerized Instructional Design: The Relevance of Guiding Principles

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Adaptive testing has a rich and ever-growing literature defining its founding principles, alternative algorithms for determining item selection and calibration, decision rules for adaptively changing level of item pools, and even sound decision rules for test-session termination. Unfortunately, adaptive computerized instructional design has little or no such foundational statements or guiding principles. Earliest visions of a technology of teaching incorporated concepts of successive approximation as they apply to programmed instruction, but there was little sophistication regarding such issues as decision rules for level changing, alternative tutorial question item design for assessing progress, etc. This paper initiates a dialog within the educational and scientific community on such issues.

The importance of the proposed dialog is demonstrated through a summary of the critical decision points confronted while developing a working multimedia-based adaptive instructional software system called MediaMatrix. The fundamental design requirements for MediaMatrix were derived from the principles of behavioral systems analysis, but details for many of the parametric standards eventually incorporated into MediaMatrix were much more arbitrarily established.

Our approach to adaptive computerized instruction is founded upon adaptive control systems dynamics and begins with a multimedia domain model of learners which targets both: 1) reading comprehension skill development and 2) video comprehension skill development. Within each of these two media/skill domains, a five-stage model of the learner's development is implemented as a continuum of "successive approximations" to truly independent learning. By targeting the ultimate steady-state goal of independence from adaptive tutorial system support, the MediaMatrix design makes specific assertions regarding adaptive system termination and reactivation. Such issues, plus the choice of tutorial item formats and the implementation of selective adaptive testing strategies for tutorial purposes, demand further scrutiny and design evaluation.

The foremost question regards the potential interaction between content delivered by an adaptive instructional system and the comprehension skill domains it targets for development. Other principles, in addition to hierarchical hyperdocument development, address such issues as: 1) the number of levels of adaptive instructional support within a given topical kernel; 2) the criterion selected for adaptive level shifts, both up and down the degree of support scale; 3) the rate and style of prompting and prompt fading utilized for each adaptive level; and finally, 4) the shifting test item criteria incorporated within the system by instructional content designers, which includes a) factual multiple choice as a representation of highest-level tutorial support, b) associational fill-blank questions as the second level support strategy, c) adaptively constructed paired-associates questions targeting semantic network development and assessment as the middle-level support, d) word associates test items as the fourth-level support, and e) review items and blank association items as the fifth and final level of support. Obviously psychometric issues of validation and item calibration, item selection, item reliability, and standards for monitoring item performance over time need to be addressed.

These and other principles, such as those determining the parametrics of time-based fluency measures within each level of support and the algorithms for adaptive item selection are also addressed. The conclusions reached summarize just how far we have come in the design of adaptive computerized instruction systems, yet how far we have yet to go to establish reasonable and understandable guidelines.
which serve both to guide future feature-set development for inclusion into adaptive systems and to guide instructional designers in their choices of content complexity, content chunking, and tutorial item incorporation within such sophisticated systems.
Why and How to Teach Hypermedia in Introductory Computer Science Courses (Summary)

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Hypermedia and multimedia have experienced a stunning growth in popularity in recent years, particularly because of the success of HTML and the World-Wide Web (WWW). Educators are therefore under increased pressure from students and the business community to incorporate HTML and the World-Wide Web as topics in all forms of introductory Computer Science courses, from literacy courses to programming courses. This paper presents selected teaching strategies and exercises (based on HTML/WWW, but also applicable to other hypermedia systems) that might be incorporated in such courses, based on the author's experiences teaching these topics. These suggestions are associated with each of four types of introductory courses: Computer Literacy, Computer Implications, Computer Programming, and Computer Paradigms.

In Computer Literacy courses, students are introduced to computing terminology, some essential concepts in computing technology, and key applications. The WWW is one of the few "revolutionary" applications, perhaps the most successful form of hypertext of the masses and many now assume that those literate in computing can author for and use the WWW. The successes and limitations of the typical keyword-based retrieval strategies available on the WWW can also motivate discussion of topics of information retrieval.

In Computer Implications courses, students investigate the ways computers are used by a variety of sectors and the implications of these uses. Perhaps the most important aspect of the WWW to discuss is its potential to act as divider or equalizer. Will it provide broader access to information for all or will it use in some groups be limited by race, sex, geography, language, social status, economic status, physical impairment, or other attributes? A closely related topic is the cost of information. Students traditionally do not think about these costs and, at least in its present state, the WWW seems to encourage the view that information is free. For information to be available through a computer system, it must be created, collected, or purchased; digitized and formatted; organized and linked; and documented. These collections are also affecting notions of copyright (e.g., Can a link or collection or documents be copyrighted? How much permission is necessary to include a document?) An equally important, but perhaps less obvious, implication of the WWW is the victory of “pretty pictures” over real information, which is particularly obvious in the transition of HTML from logical to physical markup language. Finally, one can draw upon the history of the WWW browser community to discuss the interaction between government funding, the public interest, and commercial interests.

In Computer Programming courses, students learn about computer science from the perspective of programmer, focusing on issues such as program design, control structures, and software engineering. It is possible to base such a course around one of the programming languages used in support of the WWW, such as Perl, Java, or JavaScript. However, it is also possible to use HTML as a gentler introduction to key concepts in programming. Many of the strategies that one uses to develop good webs of information apply equally to programming. HTML provides a simple introduction to the use of a structured language; the need to debug (e.g., links and design); hierarchical design and cooperation among team members (e.g., in the construction of a larger web); modifiability, portability, and reuse; and robustness and error recovery (e.g., how to lead the reader and relocate lost readers). A few classes on hypertext design and construction can introduce students to these topics and more, and ensure that they consider them throughout the course.

In Computer Paradigms courses, students learn about general theories and strategies in computer science, particularly “algorithmic thinking”, often as part of a liberal arts curriculum where the focus of the curriculum is to expose students to a variety of intellectual perspectives. Hypermedia can challenge students to rethink the way they write and organize information. Students can also discuss the need for a human- and computer-readable language to represent hypertexts, possible designs for such languages (e.g., logical vs. physical markup; markup vs. programming), and the strengths and limitations of HTML.

These are but a few of the ways that HTML and the WWW can serve pedagogical roles in a variety of courses. More strategies, ideas, and assignments appear in an extended version of this paper, available from the author.
A Review of the Research on the Effect of Learning Style on Hypermedia-Related Performance and Attitudes

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Introduction

This presentation will center on a review of almost 20 hypermedia-based studies in which learning styles have been used as a basis for comparison groups. An effective framework for categorizing hypermedia-related research is the model developed by Nelson and Palumbo (1992): hypermedia as a knowledge presentation system, hypermedia as a knowledge representation system, and hypermedia as a knowledge construction system. Hypermedia as a knowledge presentation system refers to students using existing hypermedia programs to learn new content or develop new skills. Hypermedia as a knowledge representation system refers to analyzing hypermedia from a human memory perspective. Hypermedia as a knowledge construction system refers to teaching students the fundamentals of an authoring language as well as digitizing sound and images and assigning them to construct hypermedia-like programs to reflect their knowledge of a given topic.

Learning Style and Hypermedia as Knowledge Presentation

Liu and Reed (1994) conducted a study in which the research participants responded to the Group Embedded Figures Test (GEFT; Oltman, Raskin, & Witkin, 1971). Of the 63 participants, 14 were determined to be Field-Dependent, 18 were determined to be Field-Independent, and 31 were determined to be Field-Mixed. The sample was comprised of non-native, English-speaking college students. Liu and Reed found that students, regardless of learning style (F-I, F-D, F-Mixed), increased the vocabulary competency; however, they accessed different types of features or tools and spent varying amounts of time or used the software a varying number of times.

Learning Style and Hypermedia as Knowledge Representation

Reed, Ayersman, and Kraus (in press) conducted a study in which students categorized each feature, command, and tool of IBM’s Columbus: Discovery and Encounter and Illuminated Books and Manuscripts into one of the four mental model groups: (1) semantic network, (2) concept map, (3) frames/scripts, and (4) schemata. They found that learning style, as measured by Kolb’s instrument (Assimilator, Accommodator, Diverger, and Converger), did not have a significant effect on any of the mental model percentages; that is, the percentages of Convergers’ responses, for example, as distributed across the four mental model types were equivalent to Diversers, Assimilators, and Accommodators, and vice versa.

Learning Style and Hypermedia as Knowledge Construction

Toro (1995) conducted a study in which English-speaking students were taught HyperCard. As they learned Spanish, they were to create stacks that reflected their understanding of Spanish. She used the Group Embedded Figures Test (Oltman, Raskin, & Witkin, 1971)—Field-Independent, Field-Dependent—to determine the students’ learning styles. She found that Field-Dependents produced maps with more breadth than did Field-
Independents. On the other hand, Field-Independents produced maps with more depth than did Field-Dependents.
A specific subject can be learned in many different ways. A learning situation is a very complex setting - it involves many different actors, linked to each other by various communication processes. Educational design has to determine the instructional strategy most appropriate for a specific situation.

Collaborative Group Learning

Interaction between learners is a crucial factor for the effectiveness of learning. Heterogeneity according to the learners' characteristics is an important factor for collaborative group learning. Collaborative learning within a group of distance learners can be supported by a tutor who acts as a catalyst between the individual learners, the learning material and the original instructor. The TVI (Tutored Video Instruction) method was developed some 20 years ago at Stanford University [see Gibbons, Kincheloe & Down 77] for the use of educational video tapes. The tutor is responsible for stopping the tape to foster discussion and group learning. TVI students benefit from this intensive learning model that provides a very cost effective way of learning from audio-visual material.

The TVI Model can easily be extended to support the use of other instructional media. Media can be coordinated with various tutor activities, both in work with individual students or with groups. Interactions between the different actors involved in the distance learning process can become independent of place and time by using computer-mediated communication. “Teletutoring” enables tutors to support larger groups of distance learners. The framework of such a “Tutored Media Instruction” model offers a lot of flexibility and it can respect heterogeneous group composition. Nevertheless, concerted research activities still have to be carried out, resulting in early know-how on the elements of future distance learning processes. An international group within the framework of IACCE will carry out specific test cases within different educational settings. The research will concentrate on the comparison of combinations of different values for the most important parameters that characterise a TMI situation, such as delivery formats of learning material and different forms of interaction between the learners and between learner and tutor [see Reichl 96].

Collaborative Design

Distance learning and teaching covers a wide spectrum of communication processes. What is most important is the active development of effective tools and communication channels between all the partners involved as actors in these communication processes. Stimulating co-operation needs careful moderation and appropriate forms of adjustment. A spectrum of efficient processes and activities has to be developed at interfacing units, e.g. the University Extension Centre at Vienna University of Technology [see Horvat & Reichl 94]. These processes are based on equal partnership between all parties involved and oriented towards long term goals. Experiences with this concept can be transferred to and applied for the processes of educational design and development.

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Hybermedia Learning Environment for Especially Mathematically Gifted Students for Mathematical Word Problem-Solving

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Introduction

The aim of this study is to examine the connection between the level of ninth grade students' mathematical giftedness and solving mathematical word problems in a technologically rich hypermedia learning environment compared to working in a traditional environment using paper and pencil only. We are interested in whether a hypermedia learning environment is useful in differentiating especially mathematically gifted students and developing mathematical problem-solving skills. We have examined computer-based learning programs - especially HERON [Reusser, 1995] - made for mathematical word problem-solving and on the basis of these programs we have designed a hypermedia learning environment which also utilizes stand alone application, network and ATM (Asynchronous Transfer Mode) technology. This environment and Solver application as a part of it are under construction. We have adopted contextual approaches on learning in designing the content of Solver application. Complex word problems are tied up in everyday life situations and the real world. Solver is a cognitive and didactic tool for learners. Students construct their solutions collaboratively, they construct their knowledge on the basis of earlier knowledge working in pairs in continuous interaction with the rest of the class and their teacher, too. Our view of learning is "moderate"constructivistic.

The design of Solver application

In designing Solver application we have paid attention to the special needs of mathematically gifted students - the problems are complex enough for them, too, although there are also problems that are easy enough for every student to solve. Learning environment gives a lot of possibilities for individual and independent processes for students while constructing the solutions for problems. Solver does not guide a lot during solving processes, but students can ask help and hints when needed. In Solver application properties of on- and off-line hypermedia are mixed together. Solver is made partly as an HTML document that is readable in the World Wide Web system for example with Netscape browser in PC environment. Another part of the application is made as a local Multimedia ToolBook 3.0 application. MM-WWW-PCv 3.0 program acts as an interface between Netscape and ToolBook - Solver utilizes the properties of these programs and applications together, they work in cooperation with each other.

Discussion

The purpose of Solver is to develop learners' skills when solving complex mathematical word problems. Problem-solving is one of the most important development areas in mathematics education. Significance of problem-solving processes is emphasized above all in obtaining information, but as well putting them into practice. Nowadays it is accepted that there should be possibilities to put into practice individual studying programs on the basis of giftedness. Mathematical giftedness is one of the specific domains needing special attention. We try to offer sufficiently motivating, complex and developing tasks in technology-supported hypermedia learning environment for mathematically gifted students, too.

References

Hyperstories are in some way the hypermedial version of literary stories. We propose a flexible model of an educational hypermedia software that incorporates key cognitive strategies motivating and fully involving learners by giving them control over the learning task, challenging, engaging, interacting, and adapting to the learner's level, ranging from beginning to advanced. Conceptually we define hyperstory as:

\[ \text{HS} := \text{Hypermedia}(1) + \text{Dynamic objects}(2) + \text{Character}(3) \]

where (1) is used to represent the environments and links among them, (2) are entities that have certain behavior in time and react to the events produced by users and other entities, and (3) is a special entity called protagonist that is manipulated by the user and represents the connection with the system. The model combines static and dynamic aspects of a computer environment such as a nested contexts, allowing navigation through a virtual world. The flexibility of the model supports things such as the existence of objects to be acted on by the learner, autonomous objects or characters who represent entities that live independently from users, the reusability of entities and environments to avoid repetitive work, and a clear separation between content representation and interface management.

A hyperstory is seen as the electronic version of a conventional literary story, in the same way as hypertext is the electronic version of text. However, we have improved this analogy by allowing a "dynamic binding" among characters, the world in which they move and the objects they act on [Sánchez 95]. This binding is performed by the learner, thus allowing greater flexibility in the learning process.

In other words, a hyperstory is a combination of a virtual world where the learner can navigate, a set of objects operated by the learner, and a group of characters manipulated by the learner [Sánchez 95]. Objects and characters may have their own behavior and act autonomously. Learners (when manipulating a character) can also interact with other characters to solve a given problem. Familiar environments such as schools, neighborhoods, squares, parks, supermarkets, and the like, could be interesting metaphors for building virtual worlds. Hyperstories are navigated through the use of a hypertext-like metaphor and can be good examples of powerful multimedia tools based on constructivist epistemology.

Hyperstories were built to enhance the development of cognitive structures that determine tempo-spatial relationship and laterality in early age children. We build hyperstories in order to engage, challenge, interact, and motivate learners by giving them control over stories, tools, and construction materials to build things and develop strategies to test hypothesis with the implicit idea of fostering the development and use of tempo-spatial relationship and laterality. Hyperstories motivate learners, facilitate navigation, and promote long-term learning by providing a rich context of information and making it more memorable.

Conventional hypermedia authoring tools and design techniques such as [Garzotto 95] do not provide an adequate set of facilities for building hyperstories. The static environments involved in a hyperstory (virtual world) can be simulated easily, but several aspects such as the behavior of dynamic objects and complex interactions between the main character and others exceed the conventional "nodes and links" model. The requirements satisfied by our model are: isolation of the interface from the content of the story, composition, modularity, and inheritance among entities, support of concurrent events, objects with dynamic and autonomous behavior and synchronous and asynchronous communication among entities.

In this model by using a custom-tailored specification language we can describe the virtual world as a kind of nested context model and each possible entity involved in the hyperhistory.
The ideal "hyperstory's engine" is the combination of a hypermedial engine -that deals with navigation around the virtual world- with a concurrent object-based architecture that serves objects and characters and dispatches internal and external events. In order to test our ideas we have built a hyperstory editor and a compiler operating under a MS-Windows platform to run this innovative type of hypermedia educational software.

References

Evaluating The Structural Organization Of A Hypermedia Learning Environment Using GOMS Model Analysis

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Recent advances in the computing technologies have made it possible to use various types of media. However, greater access to information does not necessarily imply a greater ability to learn from and process such information. Of concern, therefore, are effective ways to organize, present and index multimedia information to facilitate learning by students. We argue that the method of information access should be based on cognitive aspects of the users of that information [Recker et al., 95]. Instead of categorizing and organizing media based on its physical properties (e.g., text, audio, or video), we propose the use of cognitive media types for these purposes. These media types include definitions, examples, case studies, and so forth. By providing cognitive media types, the system helps learners use effective learning and reasoning strategies.

We developed AlgoNet, which contains instructional material for undergraduate computer science and engineering students, and conducted an empirical study in two classes: an introductory computer science course and the second, follow-on course. We used GOMS model analysis [Card et al., 83] to analyze students’ navigational patterns. The analysis suggests that the good novice users employed a systematic strategy of going through all the nodes simply by following the nodes. This allowed the learners to focus on the domain content in each node without worrying about which nodes to visit. In contrast, the browsing pattern of the poor learners seemed more or less random. This might have prevented them from understanding concepts enough to answer the questions.

In contrast, students in the second course used different strategies. The good learners skipped the glossary modules and focused on the application nodes. It seems that they could identify what they need to learn. The poor students, however, made a different decision after they visited the glossary module. They assumed they knew the materials covered in the rest of the modules and quit AlgoNet.

Textbooks present subject material in a specific order, and difficulty increases as students go further. Thus, students can tell how much they can skip to get to the unfamiliar subjects. In AlgoNet, however, there is no intrinsic order in which nodes should be visited or learning should occur. This may lead some students to believe they know all the materials covered in AlgoNet. The GOMS analysis revealed that some kind of serial order can help better organize cognitive media-based system.

References


Acknowledgments
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Introduction

Computers have been serving the academic community for more than three decades now. However, their role is still primarily limited to storage, organization, retrieval, and analysis of information. The latest computer technologies, like World Wide Web (WWW) [1], can offer a lot more to the academic community. Computers can now be used as an effective tool for presentation of information, and demonstration of ideas. In this paper, we share our experience in using WWW for conducting an undergraduate course.

World Wide Web as a Teaching Tool

We used WWW for conducting a course, titled "Human-Computer Interaction (CSC401) during Spring 1995. The course participants included twelve senior undergraduate students. We used NCSA Mosaic 2.0 [3] as the client software, and NCSA HTTPD Version 1.4 [4] as the server software. The server was configured on an IBM-PC compatible machine, and was accessible through the college network. The client software was installed in a PC laboratory, and was also distributed among the students. The instructor and his aides were well-versed with WWW and Internet technologies. The students were exposed to the basic concepts of WWW.

The instructor used WWW for selection, organization and distribution of reading material; scheduling, announcement, preparation and delivery of lectures; organization; distribution, and update of class-notes and other handouts; and preparation, distribution, collection, evaluation, and grading of homework assignments, quizzes, and examinations. The system was also used for submission and on-line evaluation of term projects. A number of virtual quizzes were given to the students. In addition to the normal office hours, instructor also observe virtual office hours. A few special virtual classes were held during the semester. However, only text was used as communication media during these virtual classes, primarily because of the limitation of available resources.

The system was also used for interaction among the instructor and students. Such interaction included administrative announcements, sharing information, and conducting virtual question-answer sessions. An interactive form was created so that the students can communicate with each other and with the instructor through email. The home page for the course also contained a link to the newsgroups related to the course. A local newsgroup was created so that students can share information among each other. Further details about the experiment are provided in [2].

Conclusion

We could not use WWW technology to its fullest potential, primarily because of the time constraints, limited resources, lack of training and expertise, and unavailability of the supporting tools. We are enhancing the system to include additional features, and plan to use it more extensively in future.

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MultiWorlds-II Multimedia Microworlds Instrumentation Tools

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Investigation and analysis of various approaches to the development of an ideal computer model of learning process suggest that the student should have two environments in his computer: one is for working with "real" objects and phenomena, the other is for working with "abstract" objects: definitions, images, formulae, etc. Combination of these environments including the models of the subjects of learning, the tutor and the student, allows for realization of the most complete, in our opinion, model of learning environment, the main components of which are as follows:

- World of actions - the world of physical objects and phenomena (workshop, laboratory, etc.)
- World of knowledge - the world of definitions and rules (textbooks, handbooks, video tapes, etc.)
- Tutor Agent - a subsystem providing the pedagogical support of the learning process, delivers lectures, consults, asks test questions, assesses the student's work and enters the results in a special protocol.
- Student Agent - an executor of the student's commands in the environment. Ideally, it ensures all phases of cognitive activity: perception, planning and execution in the automatic mode. In a broad sense, it is a student's anthropological model in the "Worlds".
- Tools and instruments - student's resources provided by the environment for the execution of the tasks.

This computer environment has such components as:
- Lecture: is a specially arranged theoretical material presented as static and dynamic pages (screens), each including various forms of information: hypertexts, illustrations, animation, audio, video, graphics, etc.
- Test question: is a multiple-choice question.
- Practicum: creates a real problem situation on the screen requiring solving a real task (for example, to establish the reason for a malfunction in the car operation, or to make a cake).

Learning path: is a specific sequence of lectures, questions, practicums; the choice of these components can be determined either by the student's level or by the depth of penetration into the material depending on the final goal of the learning process.
Thus, the creation of a computer environment representing a system of interconnected objects, using the multimedia technology as an expressive means of presenting objects, their properties and interrelations, processes and phenomena, offers a scope wider than in traditional learning environments to simulate the learning process, problem situations arising with its frames and various scenarios of actions. In this case, the student becomes an agent in this world, a participant in all events taking place in this computer environment.
The Effects of an Interactive Learning Environment on Learning Styles

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Computer-assisted instruction (CAI) has grown dramatically despite a lack of evidence of its contributions to teaching and learning (Roblyer, et al. 1988). Criticisms center mainly on the mindless structural drills, inability of the computer to deal meaningfully with unanticipated responses, and not allowing students to construct their own meaning (Jonassen, 1996). This is particularly true in the teaching of language skills. However, with adequate hardware and software and integrating CAI with a course structure tuned to communication-based learning, a more effective interactive learning environment (ILE) with teachers and computers working seamlessly together to cover each other’s weaknesses may result. Presentations and simulations using full-motion video supplant drills as the mainstay of the ILE courseware. A database of about 100 hours of multi-branching ILE courseware makes simulation of human communication realistic enough to satisfy most students. An assessment mode in which students set their own achievement levels, class schedules, lesson content and syllabi in negotiation with their teachers goes further than traditional CAI in allowing the students to construct their own meaning. However, such an ILE assumes that students think and act in a uniform manner although they actually differ in their learning styles and strategies (Chapelle et al., 1986). Learning style theory suggests that everyone learns in a cyclical process involving different styles such as doing, listening and observing. However, the level of these styles and preferences for their use differ between individuals, resulting in most having one predominant style which predisposes them to learn most efficiently when their learning experiences are matched to it (Wilson, 1986). If that is true, any ILE’s usefulness is limited as it may only benefit some students while others with different learning styles may learn better in traditional teacher-taught classes. In the fall of 1995, UNIMAS, using ELLIS™, created an ILE as described above for 110 freshman students to learn English on a self-access basis monitored remotely by their teachers who did no overt teaching. A comparison group of 58 students learned English in traditional teacher-taught classes. Two different TOEFL tests set 16 weeks apart were used as the pre- and posttests for both groups. A Learning Style Inventory (Hinkelman et al., 1992) administered to the students found 19 doers, 71 listeners and 20 observers in the experimental group while the comparison group had 11 doers, 36 listeners and 11 observers. Using the ANCOVA test on the posttest scores with the pre-test scores as covariates, no statistically significant difference was found in the scores between the three learning styles \([F(2) = 63, p = .532]\) or between the learning styles and the two instructional methods used \([F(1) = 1.94, p = .147]\). However, the scores for the two instructional methods were significantly different \([F(1) = 9.52, p = .002]\). The mean pre- and posttest TOEFL scores for the experimental group were 458 and 501 respectively. For the comparison group, these were 427 and 449 respectively. The practical significance of the treatment was 68.7%. It is gratifying to see that the ILE was robust enough to cater to all learning styles indicating that CAI, properly used, has an important place in language teaching. The difference did not stem merely from replacing the teacher with the computer or from using a powerful courseware but also from the infusion of communicative learning principles into the software’s design and the course structure and management, thus creating a very conducive learning environment for students of all learning styles. This ILE has now been adopted by UNIMAS for its freshman English Proficiency Program.

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A well-established principle for the design of learning environments is that learner-engagement is the key to learning effectiveness [see Gagné 1985]. Learner engagement, however, remains problematic because it is the learner’s cognitive engagement with the learning environment and associated learning materials that is the critical factor, and cognitive engagement is not easily detected or measured [see Spector 1994]. One method of achieving a generally high level of cognitive engagement has been through the use of system dynamics based learning environments [see Davidsen 1994].

System dynamics based learning environments typically consist of these elements: an introductory tutorial; an overview of a dynamic and interactive model of a complex phenomenon; learner access to model variables; opportunities for learner manipulation of model components; requests for learner interpretation of simulation runs; and opportunities for learner construction of alternative models. Feedback and discussion are integrated throughout the learning experience. Cognitive engagement is achieved by establishing a clear context for learning, by facilitating learner control, and by introducing unexpected outcomes in need of explanation and exploration. Such environments begin with an enabling phase explicitly supported by the introductory tutorial. Next is a processing phase in which learners become increasingly involved with the underlying model and its manipulation. The learning experience concludes with a resolving phase, consisting of group discussions of various experiences interacting with the model.

Evidence indicates that effective simulation-based learning environments can be constructed with instructional strategies built into the simulation engine so that as simulations are created they have inherent instructional value [see Towne 1995]. System dynamics based learning environments can be regarded as an extension of this technique, and they have the additional advantage of allowing a wide variety of individually responsive learner interactions to be designed and facilitated.

References


CBL Evaluation: The Why’s, What’s & How’s

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Introduction

Development & usage of CBL is a commonplace activity today, whereas evaluation of the effectiveness of the CBL material as a teaching / learning medium is a key and often neglected issue. The evaluation of a CBL product involves three activities: understanding the product’s teaching and learning objectives and its intended audience; gathering evidence regarding its use and effectiveness; judgement of the product based on the evidence. As experienced developers of Computer Based Learning (CBL) materials for use in undergraduate computing modules, we have, during the academic year 95/96 undertaken some trials of CBL material with groups of students that has involved evaluation of the student learning experience.

Features of Evaluation

Evaluation is required to assess the quality of the CBL product. Any CBL product has two main components: the software component as it is a computer based activity; the didactic component as its purpose is to instruct. Therefore, evaluation should address both facets if the quality of the final product is to be assured. For the CBL developer, only through evaluation will feedback be gained that will enable improvement in the quality of the CBL product. Evaluation of the CBL product involves a two pronged approach, firstly from the point of view of a content expert who is concerned with the totality and credibility of the subject matter and secondly, from the point of view of the potential student user. While we are aware of the former this paper is primarily concerned with the latter.

In evaluating a CBL product we need to elicit from the student user: the teaching / learning effectiveness of the product; the usability of the product with respect to ease, consistency & clarity of use; the usage of the product with respect to users wishing to have access to it. The approach taken has been to use: a short test paper that addresses the learning objectives derived directly from the CBL material [Laurillard, 1993]; a questionnaire that addresses navigation, usability and other HCI issues[Barker & King, 1993]; video to record student experiences with the material; student interviews to provide additional open-ended feedback [Elthe, 1995/96]. The test paper was used twice, firstly as a pre-test and secondly as a post-test and the student performances compared. The paper took the form of a number of multi-choice questions that covered the learning objectives of the CBL material, students were also required to indicate their confidence when making a particular choice[Gardner-Medwin, 1995].

Conclusions from Evaluation

In conducting the evaluation with different but typical student groups a number of problems materialised: student attitudes to CBL; availability of access to CBL material; evaluation timetable. We believe that the problems experienced are not unique to Glamorgan or the particular CBL material content and raise question about conclusions drawn from any evaluation. By being aware of the problems that may arise, the evaluation events can be planned to minimise their effect and thus provide more credible conclusions. After addressing the problems uncovered the evaluation produced some very positive initial results regarding the student learning process.

References


The CORAL system was proposed to achieve the goal of distance education by establishing an interactive and collaborative learning environment on computer networks. The primary goals of this group project include: 1. exploring various interactive and collaborative learning schemes in the context of distance education, 2. creating a cooperative learning environment on the Internet, 3. producing prototype courseware units designed for the cooperative environment, and 4. conducting research to examine the effects of using courseware.

The focus of the CORAL system, as indicated by its name, is distant cooperative learning based on computer-mediated networks. Students can access courseware via networks at any time and any place; moreover, they can have learning partners with which to discuss problems they encounter and work together toward solutions. Motivation to learn is expected to increase significantly in such an environment. And, too, teachers can enjoy an excellent instruction management environment, monitoring individual student progress and obstacles to progress and provide assistance when needed. Furthermore, from an educational research standpoint, the information collected on multimedia networks can be used to build an objective and dynamic learning model without interrupting students' learning processes.

We have been developing hypermedia courseware on the Internet that can be used for self-paced learning by employing a MOSAIC-like browser. We collected information about students' learning activities when they were using these products, then analyzed the learning patterns to build student models. The pedagogical strategies developed will be used to adjust the courseware and discussion interfaces.

The CORAL system was designed primarily to encourage cooperative and collaborative learning. To accomplish this, the system had to incorporate functions that facilitate communication, and learning tasks arranged for cooperative work. Otherwise, students would be unable or unlikely to learn individually in conjunction with other students. Accordingly, we designed certain features into the CORAL system that promote cooperative and collaborative learning: 1. audio-video windows, 2. private notebooks and shared notebooks, 3. a requirement that students form teams of two or three to do group projects, such as programming tasks, 4. In the future, a student tutor system, as suggested by Hiltz (1994) will be included in the CORAL system. We expect that more research will be conducted on the cooperative distance education environment, and systems like CORAL will be developed to benefit students, individually and cooperatively, locally and remotely.

References

Exploring the Role of Video in Learning from Hypermedia

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Plausible explanations have been given for expected enhanced learning from hypermedia, in particular, that the integration of video therein enhances learning from it, but these are ill-tested [Kozma, 1991]. Although the effects of video on learning have been well documented [Howe, 1983], the claims for video in hypermedia have not been well explored. This paper investigates such claims by comparing responses to, and recall from, hypermedia materials with and without integrated video segments. It reports on two studies of adult students’ learning from hypermedia materials adapted from two chapters of Set On Freedom, a commercial application on the civil rights movement. The chapters centered on the people, places, events, and ideas surrounding the Brown v. Board of Education Supreme Court ruling and the Montgomery bus boycott.

In both studies, graduate students of education were asked to explore the hypermedia materials for approximately 45-minutes. Half the subjects saw the chapter on Brown v. Board of Education with video segments included, and the chapter on the Montgomery bus boycott without video, while the opposite was true for the other half of the subjects. Immediately after exploring one or the other version, all subjects were asked to summarize each event. Their responses were analyzed for length and affective content, and compared between and within groups. One week after exploring the materials, all subjects were given a short-answer identification test containing seven items from each chapter. These were scored for correctness in each chapter grouping, and compared between and within treatments. In addition, both summary and item identification data were collapsed across groups (see below) and instances in which subjects saw or did not see video compared.

<table>
<thead>
<tr>
<th>summaries</th>
<th>item identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>chapters with video</td>
<td>78</td>
</tr>
<tr>
<td>chapters without video</td>
<td>72</td>
</tr>
</tbody>
</table>

T-tests comparing collapsed data reveal that, while there were no significant differences between the lengths of the summaries of chapters in which subjects saw or did not see video (p>.10), they were able to correctly identify more items from chapters in which they saw video than from chapters in which they did not see video (t_{40}=2.42; p<.05, Study I; t_{68}=2.71; p<.01, Study II). The results provide good evidence that video can indeed enhance learning from hypermedia. They also suggest two possible, perhaps complementary, explanations for such enhancement -- that video adds an affective dimension to hypermedia materials [Howe, 1983], making them more meaningful, hence more memorable; and/or that video is represented differently from text in memory, and that such representations are more complex and so provide more links to elaborated knowledge therein [Baggett, 1989].

References


One of the major dilemmas facing colleges of education across the country is how to incorporate technology into the preservice curriculum. Technology does not appear to be central to the teacher preparation experiences in most colleges of education. To address this dilemma the College of Education at Winthrop University is examining the role of technology and how best to incorporate its use across the teacher education curriculum.

Coordinating Technology with a Conceptual Framework

Before planning how the incorporation of technology can best be achieved, it is necessary to examine the conceptual framework that guides the core education curriculum. In this case the conceptual framework is organized around five major concepts: the learner; the society; the curriculum; the teacher; and the educational leader. The use of technology has been infused into each of these categories at three competency levels: exploratory, preprofessional, and professional stages. Examples include using technology to access information at the preprofessional stage in the teacher strand and using databases, authoring programs, and other data retrieval systems at the professional stage of the curriculum strand. Without this guidance in the core courses, it is difficult to proceed to more specific uses as well as more detailed means of assessment.

Developing a Technology Rubric of Competencies

Once the decision is made to infuse technology across the teacher education curriculum, the issue of assessment becomes paramount. How can the various uses of technological tools be assessed both independent of and integral to the courses within which they are embedded? One suggestion is to examine skills and strategies that technology will enhance within the discipline and throughout multiple disciplines. Three important skills surfaced that, regardless of the content, are infused in all curricula: the ability to communicate; the opportunity to collaborate; and the ability to construct meaning. After identification of these strategic skills, it was easier to address HOW these could be reinforced within each of the content areas. For example, to communicate information is was easy to link to telecommunications and word processing activities. To promote collaboration is was clear that previous efforts at grouping students together for a shared technology project would be a sufficient start. And to reinforce the construction of meaning through technology it was apparent that the authoring tools, such as HyperStudio and HyperCard, would fit nicely into the emerging paradigm. Once the HOW was addressed, assessment was less constrained and a rubric of competencies ensued.

Conclusion

Like many colleges of education, Winthrop University is striving to integrate technology into the teacher education curriculum in a manner that coordinates with the conceptual framework that undergirds the core curriculum and to provide guidance for the infusion and assessment of technology across the curriculum.
A WWW Based Interactive Hypermedia Tutorial

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Introduction

The World Wide Web is a new medium that has expanded rapidly over the past year. It brings hypertext, multimedia, desktop publishing, and global networking into one entity. In other words, all forms of media, i.e. video, audio, text, and images can be stored and accessed using the Internet. Because of these advantages and capabilities, the Motor Learning Lab at the University of Pittsburgh made the decision to explore and apply this new technology to the development of a WWW based interactive hypermedia tutorial: The Fundamental Motor Patterns.

After four months of research and analysis, an instructional design team was formed, content was specified, hardware and software were specified, the goals and objectives were identified, and the evaluation plan was established.

Environment

The Computing and Information Services (CIS) of the University of Pittsburgh set up a campus-wide networking and dial-up system to provide all faculty, staff, and student access to the University network. Each computer lab was configured for full function Internet access. Every enrolled student can use any type of WWW browser, such as Netscape or Mosaic, to access information on the web. E-mail and listserv services are also available. While at home students can dial-up and connect to the network at the university.

A password is required for those who want to access the tutorial, which is located on the Motor Learning Lab's web server. By using the customized Common Gateway Interface (CGI), students' responses and progress were recorded and stored automatically in the database for further analysis by the instructor.

Goals and Objectives

In order to maintain instructional effectiveness and to establish a collaborative learning environment, the following goals and objectives were identified: 1) provide an interactive hypermedia on-line learning environment, 2) provide a flexible and easy access environment, 3) provide personalized on-line feedback, 4) protect students' privacy, 5) encourage Collaborative Learning, 6) provide student progress monitoring capabilities, and 7) help students to keep up with their assignment.

Summary

By using the Internet and WWW technology, students and faculty at the University of Pittsburgh Motor Learning Lab are not only able to enjoy the advantages and capabilities of the interactive hypermedia tutorial, but are also providing valuable insight into how the technology can be effectively utilized for instruction. Currently, the materials developed for the tutorial are only available for those students taking the course, however, plans are being made to offer the course to other universities upon request.
At my university I continue to struggle with how to utilize technology to develop distance learning strategies that would be equivalent to or greater than the learning outcomes achieved in the more traditional courses. Courses best suited for online instruction are those that invite discussion, knowledge-based opinion-sharing, and debate, rather than those which deal with concrete facts or procedures. The text only nature of many online environments makes science and math difficult to render at least without extensive multimedia or a web based environment. Using instructional television, compressed video, multimedia, CD-ROM delivery systems are nice, but currently are still too expensive for many colleges and universities. Using e-mail and usenet (or conferencing software) has the greatest benefit in courses where student interaction and discussion of material and issues is encouraged as a way to build students' understanding of course content. I have taught three different courses since 1994 using online techniques. The courses are taught using only my university's dialup system and prerecorded videos the students are allowed to check out for the semester. In the courses I opted to keep things simple (and inexpensive) by sticking to simple e-mail and a Usenet News reader with optional web assignments. I have an optional orientation to help students to establish their university computer accounts otherwise everything is done with e-mail or usenet and no campus visits are required.

The general structure of my online courses is as follows. Since most of my students are adult learners and thus have family and careers, I choose to make Friday the first day of the class week. This gives them the weekend, up front, to begin their work. Thus, on day one I would post the online questions and assignments to Usenet News and, if appropriate, send a lecture to their e-mail directory. Days two through seven would consist of student responses based on the readings, to my initial questions and to each other. The students are required to log on at least three times for each assignment (each week) and only one log on per day would count toward their discussion grade (although sometimes they would log on more than once per day and this was okay). I reviewed their comments daily, including weekends, to answer questions, keep the discussion on track, and often to offer my observations on their comments. I asked them to keep each online response to no more than three screen fulls - about a page of material. At the end of the week I would grade them on their comments in terms of their understanding of the assigned material and their participation in the discussion. Their grade would then be e-mailed to them. I gave three take-home exams and had no assignments the weeks they were working on the exams. The exams were e-mail or faxed to me.

In conclusion let me mention some points and issues that probably apply to most all online approaches. A syllabus in any DE course is very important and should be laid out clearly and precisely. Remember, you will not have class days to clarify your remarks. Your syllabus will contain not only the traditional information (evaluation, assignments, etc.) but computer information as well. If possible, ask your Dean to limit your class size to no more than 20 students with 10 to 12 being optimal. If done properly, it takes more time to teach online course than a "normal" nontraditional or even a classroom course. You have to read all of the student responses and comment on them in a timely manner. Logging on everyday is important in order to keep up with the discussion articles and threads. Finally, have a phone-in help desk with a sympathetic and knowledgeable person available. It is important that this desk be open in the evening and some on the weekend. You do not want your students spending more time trying to figure out a computer problem than they do working on your assignments.

Creating an environment where the student masters new information, develops critical attitudes and values, and learns how to analyze and synthesize are still the domains of higher education. As with any educational paradigm shift, instructors who teach online must continually strive to create a quality learning environment which focuses on scholarship and content based learning.
Introduction

In an algorithm animation environment, the dynamic behavior of algorithms can be explored and uncovered. Through the use of multiple graphical displays, all views are updated simultaneously in real time as the algorithm is executed. New algorithms, graphical displays, and input generators can be implemented and run with existing libraries of these components. Such an environment makes use of the concept of a script (typically used as high-level macros) to allow interactiveness. This project started with the implementation of an animator for specific algorithms (ALGANI 1). This system was later revamped to become a generic algorithm animator (ALGANI 2). The scope of a generic algorithm animator is very wide; thus to reduce the scope, only a few basic requirements were selected to design and implement ALGANI 2.

A specific animator: ALGANI 1

In the first phase of this project a teaching tool was developed that could animate some commonly used algorithms such as sorting, graph and BST algorithms. These algorithms were hard-coded into the program. To enable the user to have a better understanding of the algorithms, the display and animation were made unique to each algorithm.

A generic animator: ALGANI 2

Being generic, ALGANI 2 would not be able to animate all algorithms satisfactorily. The quality of the animation would depend very much on the effort put in by the user developing it. To realize ALGANI 2, two important components were identified: a graphical editor and an animator.

Graphical Editor

The editor allows users to edit the shapes and sizes of the object they wish to use when animating the algorithm. The features supported were those found in simple graphical editors like clearing the window, zooming in and out, grid on and off, saving and retrieving from a file. Grids within the drawing window were implemented to enhance animation. Another important feature is the ability to zoom an object in and out. This feature ought to be implemented as a basic part of the software requirement, or else future upgrading will be more difficult.

Animator

The animator allows the user to compile an algorithm and to activate an animation. Using this animator it is possible to animate an algorithm by first creating objects using the graphics editor. Following this, the user can build algorithm files with the standard libraries to define the motion of objects. Lastly, these algorithms can be ported into the animation environment. This is accomplished through the following steps:
1. Open a pipe to allow ALGANI 2 to issue shell commands.
2. Compile the algorithm source code with the animator library and report possible errors.
3. Execute the compiled program while listening for requests.
4. The executable file sends animation commands to ALGANI 2 through the pipe.
5. ALGANI 2 decodes the commands and performs the animation accordingly.
After implementing the BST insertion algorithm into ALGANI 2 it was concluded, that the quality of animation using ALGANI 2 is only slightly inferior to ALGANI 1, the source code is shorter, and the time spent for implementing the animation using ALGANI 2 is much shorter.

At this stage, ALGANI 2 can only animate some simple algorithms satisfactorily. When the complexity of an algorithm grows, the animation would become more abstract due to the restricted set of animation commands (e.g. MOVE and INSERT) available. This also means that to be able to understand the animation, the user would need to know the symbolic meanings of each objects on the display.
Combining Interactive Multimedia and Inquiry Teaching to Build an Intelligent Multimedia Tutoring System

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Introduction

Over the past years, the development of Intelligent Tutoring Systems (ITS) and multimedia courseware has been rapidly expanding. High level multimedia courseware packages for certain topics in the domain of teaching are widely available, e.g. in mathematics, physics, chemistry. Even with all these sophisticated multimedia features added these programs still remain on the same level as a text book since they are not able to adapt to the students’ ability to understand and learn. The problem with these packages is that they lack intelligent features. The student may only be guided through the course and has only limited possibilities to interact with the program. Questions can be answered and even hints might be given if the solution is wrong, but the program is not able to monitor the students progress or interfere if the student is on the wrong track.

The main goal of this IMTS is to illustrate to the students the behaviour of algorithms applied to complex data structures and to give them the possibility to manipulate these data structures interactively. The performance of the students will be monitored and guidance towards the correct solution will be given using methods of inquiry teaching. The IMTS supplements lectures, tutorials and laboratory exercises and is always available for them when qualified lecturers are not in reach.

Design of the ITS

Current courseware is generally not able to adapt to an individual student’s capability. With an ITS it is possible to overcome some of these problems. The system can monitor the students’ answers during the teaching session and upon encountering problems it is able guide the student towards the right answer [Looi et al. 1991, Wong et al. 1995]. The method of guidance depends on the inquiry teaching method chosen, e.g., Socratic dialogue, Piagetian learning, coaching [Collins and Stevens 1991]. The system might prompt the students on the prerequisites required in order to answer the question or show a different way to approach the question. The system also has the possibility to move back to an earlier topic if it discovers the students' knowledge is not sufficient. In order to make the teaching more efficient it will be studied how these methods can be combined and whether it is advisable to change the teaching method if the student does not progress with the current one used.

Advantages of Multimedia Support

Understanding data structures depends a lot on visualising the problem, e.g. binary trees, graphs. These are difficult to teach given the limitations of the lecture format. Demonstrations using computers or videos can be made but it is not possible to pay attention to the individual students needs during the lecture. Further some weaker students might have difficulties understanding concepts that cannot be reviewed in the lecture because of time constraints; further, a textual explanation might not be sufficient for them to understand the concept. An alternative display of the problem using intelligent and interactive multimedia might increase the understanding of the student. Reasons to add multimedia to an Intelligent Tutoring System include the following:

- the course material can be presented in a more interesting and stimulating way using multimedia
- data can be presented differently according to the students understanding of the problem
• the student can interactively manipulate data structures and have the results analysed
• instructions, guidance and acknowledgement can be given to the student by voice instead of text output.

References

Digital Multimedia (DM) systems utilize information in the forms of text (words), tables (numbers), audio (voice, music, & sound effects), graphics (symbols, charts, icons, images, graphs, & photos), digitized and analog motion video, and animation. Artificial Intelligence technologies, especially knowledge-based systems (KBS), capture and reproduce the complex decision processes of experts in the form of heuristics, inference, decision rules, and metaknowledge, enabling them to provide intelligent assistance and decision support.

DM technologies can present rich information which engages and stimulates the user and can increase the understanding and retention of the material which is presented. Yet DM systems are resource intensive, expensive to develop and maintain, and do not store or retrieve information intelligently (most use linear or logically simple algorithms for sequencing logic). KBS can provide a means to share scarce knowledge across space and time, and can find satisfying answers to logically complex problems more consistently and often faster than a human decision maker. However, KBS usually provide only a static text display of the advice (not rich content).

There is outstanding opportunity for synergistic relationships if implemented together, thereby having a dramatic impact on decision outcomes. KBS can provide intelligent storage, indexing, retrieval, and distribution of DM elements in a system. The explanation facility in KBS can be enhanced with the addition of DM technology. Similarly, DM interfaces allow KBS to be applied in knowledge domains that use non-verbal and perceptual expertise. KBS utilization rates can be improved when DM make them more visually appealing and less intimidating. In addition, sound effects and digitized video from a knowledge domain can improve the effectiveness of knowledge acquisition activities. KBS can enhance DM systems by applying heuristic knowledge to the task of determining which multimedia element to display on the screen or send to the speakers. Heuristic KBS logic could be embedded into a system to identify the appropriate DM elements to display based on the user’s previous inputs, thereby creating an intelligent multimedia system.

In summary, systems incorporating both digital multimedia technology and KBS technology have the potential to achieve far greater effectiveness than systems which include only one or the other. The synergy found between digital multimedia and knowledge-based systems can take the form of

- KBS with DM front-ends for providing a more effective mechanism for acquiring user input,
- KBS with DM output to generate more effective presentations of advice and conclusions, and
- DM systems with embedded intelligence (e.g., intelligent multimedia tutorials)

Note: Space limitations of this format preclude the presentation of example integrated systems, conclusions, and bibliography. Greater specificity will be presented at the conference.
Multimedia and Virtual Reality in Instruction:
Some Risks of Virtual Learning

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It is ironic that as Multimedia and Virtual Reality technologies become more sophisticated, less expensive, and easier to use, the potential risks in using them in instruction are exacerbated. Specifically, (1) the emphasis upon visual artifacts may compromise the efficacy of competing print media, and (2) the disintermediate nature of the technologies could atrophy learner socialization skills.

McLuhan (1969) argued that increased proliferation of visual media would eventually change the way students learn, that cognitive processing would grow increasingly dependent upon imagistic modes of information representation, and that the efficacy of print-oriented instruction would be undermined. Educators have been quick to subvert McLuhan’s notion with arguments derived from Learning Style and Information Processing theories—that computer multimedia-based instruction should optimize learning conditions because it allows access to information in verbal, visual and auditory modes, one of which represents a student’s most effective learning style.

One problem with this model is that it ignores the growing body of empirical research indicating that students in multimedia computing environments tend to activate visual information nodes much more often than verbal, and do so because they find that particular medium easier and more interesting. Another problem is the assumption that students select information in representational modes that are commensurate with their own learning styles. Such an assumption ignores the possibility of arbitrary preference. What if students select certain nodes for novelty reasons; perhaps that digitized video simply “looks cool,” or maybe that animation reminds them of their favorite Saturday morning cartoon.

Novelty poses a similar risk to the integration of computer-based Virtual Reality in instruction. The ability to navigate in real-time through a three-dimensional rendered world can easily hide the fact that the VR environment is an artificial, contrived and extremely limited facsimile of the original. Educators need to be particularly careful about choosing when virtual environments are more appropriate than actual physical experiences; some environments might better be explored physically than with computer-generated models. Given the ease of use and cost-effectiveness of the technologies, the risk of “overusing” them is very real.

The use of Networked Virtual technologies, like World Wide Web, suffers a similar risk—the loss of social presence. Particularly on low-end systems, handshakes, smiles and other physical gestures that convey sincerity, interest, and warmth are reduced to semicolon winks and line-art signatures. Opportunities to interact dialogically with others online are limited primarily to bulletin boards and email; real-time chat systems are plagued by the anonymity of user I.D.s, text-only interfaces, and non-asynchronous message transfer.

Are emerging technologies like Multimedia and VR producing only “virtual” learners, students who have compromised literacy and socialization skills? Educators must recognize that it is indeed the ease of the medium that is the message—that Multimedia, Virtual Reality and other emerging technologies can inadvertently de-skill today’s students in verbal modes of processing and communicating. Much research is needed to identify not only the specific curricular conditions under which these technologies augment learning, but also the specific conditions where their efficacy inadvertently impedes the development of other skills.

Works Cited
Training Environment

The National Cryptologic School (NCS) is the training arm of the National Security Agency (NSA) and as such is responsible for procuring or providing all the training to maintain and develop the skills of NSA's workforce. NSA's size and level of automation (nearly every employee is connected to an internal network) suggest that heavy use of Commercial-Off-The-Shelf (COTS) CBT could be made for standard topics; but the agency's need to follow the leading edge of many different technologies also requires internal development of courseware.

Evaluation Tools

Whether courses are commercially or internally developed it is still useful to the training school (and the student) to determine what was learned. Many of the commercial CBT products we have purchased include no student evaluations. To support the development of Web-Based CBT, a suite of tools to deliver (and in some cases, grade) on-line evaluations were developed as cgi-bin scripts for the web.

The first tool is the "Original Quiz Generator" (OQG). When the student is ready to take a quiz, he or she inputs identifying information into an html form (name, phone number, e-mail address) and invokes the script with the click of a button. The script (running on the server) searches a database of ASCII files, randomly selects a preset number of questions, and e-mails them to the address provided by the student. It also mails the course manager a list of the questions that the student received. The student can then answer the questions in the format of their choice: move the message body into an editor and type in the answers, or print the questions and write the answers by hand. The answers can then be returned for grading either by electronic mail or internal (snail) mail. The message that is sent to the student has the course manager's e-mail address as the "from" field, so that the student can easily send his answers to the proper location. The message sent to the course manager has the student's e-mail address in the "from" field, so it is easy to cross-check that the student attempted the problems assigned.

The other two tools work together as a team. The "Multiple Choice Quiz Generator" (MQG) and its related grading program produce and grade multiple choice style quizzes in real-time as web pages. Invoking the MQG is done in the exact same way as the OQG, but instead of preparing a mail message, the MQG builds, on-the-fly, an html form web page, where the answers to each question are radio buttons [Aronson 94]. Selection of questions is still made from a database of ASCII files; the selection and ordering of questions is randomized. Even the order of the answers is randomized (in one of three way: not at all—for efficiency; completely—to discourage student cooperation: and all but the last answer—to support "none of the above" and "all of the above" answers).

Since the quiz itself is a form, once the questions are answered, a simple key click can be used to invoke the grading script, with the student's selections as input. The results are returned in two forms: one as a web page to the student and as a mail message to the course manager (for record keeping). The results page includes the correct answers, where needed; however, a results page is only prepared when the student has answered at least some questions.

Enhancements and Applications
The tools could be enhanced to enforce time limits or provide multimedia (i.e. not just text) questions; currently there is no customer demand. The tools could be used to provide pre-tests (for any type of class), equivalency exams, homework or the evaluation for a COTS CBT.

References

The Application of Hypermedia Technology in Foreign Language Education: The Experience in Designing a Chinese Language Course

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In recent years, while much concern has been expressed about the learners of the Chinese language and their mixed entry proficiency levels in Chinese classes, few reports have stressed possible alternative ways to meet the individual needs of the learners with special consideration given to their different academic goals, their linguistic background and performance, and their attitudes toward the target language.

In order to provide a greater variety of meaningful practices appropriate to the different proficient levels of Chinese language learners, Chinese pedagogical professionals encourage more exploration into technology-based instruction for Chinese. They suggest that computer-related technology (e.g. Hypermedia technology), with its current hardware flexibility and powerful memory capacity, may be one of the variable methods of presenting all kinds of communicative and interactive teaching ideas in a practical way.

Indeed, a hypermedia system is a multi-format knowledge base that enables users to gather information through a non-linear sequence. Its non-linear characteristic will meet learners' dynamic needs or interests, and its multiple information formats will arouse learners' attention and better represent information. Language instruction, which needs information formats other than text and needs vivid context to allow learners' active exploration, may benefit from its adoption. Yet, instructional designers criticized that most existing hypermedia systems are basically not intended for instructional purpose. These systems provide too much learner-control and cognitive overload. Inexperienced learners are frequently lost in navigation and miss important information due to confusing branching and inadequate directions.

Based on Gagne’s Instructional Events theory and the current proficiency-based languages theories, this study proposes comprehensive and communicative strategies to enhance the instructional value of hypermedia products. When developing this situation-based language courseware, the authors have tried to integrate as many instructional elements as possible into the courseware design.

A unit on “Shopping in The Market” has been designed to illustrate the important instructional features of this language courseware. A picture of a typical Chinese market with shoppers buying groceries is presented on the screen as the “Title Page” to arouse learner’s interest. “Learning Objectives” of this unit are automatically listed after showing the Title Page. After knowing what is expected of this unit, the screen goes back to the picture of the “Chinese market”. Several content buttons appear on the sides of the screen to provoke students to explore. The buttons contain options of “Pretest”, “Reading Text”, “Grammar/Patterns”, “Listening/Watching to the Dialogue”, “Posttest”, and “Ending”. Within each option, there are sub-menus providing choices for practice or for feedback. Additionally, an “Assistance” button is provided for the learners to get on-line help and operation guides, learning advisement, and content maps of this courseware. To remedy the lack of “instructional control” problems posed by conventional hypermedia designs, the authors utilize models based on “Controlled Random Access.” With instructional strategies and content delivery in mind, this presentation flow allows sufficient interactivity and flexibility of learners’ selections to jump from one information screen to another screen or from one section to another section randomly.
TELECOM: An Analysis of Hypermedia in Higher Education

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TELECOM, a hypermedia-based software tutorial was developed to teach graduate business students basic terms and concepts related to the subject of telecommunications. This paper is about the TELECOM tutorial and the methodology by which it was constructed.

TELECOM is an organized set of interactive lessons. From the Table of Contents page a user may navigate to any of four main tutorial components: 1) Introduction, 2) Introduction to Telecommunications, 3) Model of Telecommunications, and 4) Networking. Learning objectives drive each component and a student chooses components according to his/her needs. For instance, if someone understands basic principles of telecommunications, he/she could click on networking, in effect skipping over elementary concepts. As an alternative, students may commence with any other topic. The Introduction section provides a brief lesson about how to use the tutorial. The second tutorial component, Introduction to Telecommunications, introduces a general model of communications. The Model of Telecommunications component shows basic parts of a telecommunications model while the final component of the tutorial covers networks.

A graduate student and I designed and developed TELECOM. We followed a typical iterative development approach that included three overlapping stages: 1) Planning, 2) Design, and 3) Presentation. We used criteria recommended by Jacques, Nonnecke, Preece, and McKerlie (1993), adapting it to evaluate our particular product as it evolved. The six criteria, identified by Jacques, et. al. as essential aspects to evaluate educational hypermedia include 1) purpose, 2) content, 3) structure, 4) navigation, 5) control, and 6) presentation.

Stage 1: Planning. Planning, an essential part of any development process, started with a review of previously developed hypermedia-based lecture support material. During the planning process, we focused on learning goals or objectives associated with the subject matter.

Stage 2: Design. Jacques, et. al. see the process of navigating as the means by which relationships are revealed to users and also the means by which users control the learning process. We designed the tutorial to provide effective navigation between and among topics, and to allow the user to select sections of the tutorial that they desired.

Stage 3: Presentation and Development. Effect, impact, and success are suggested by Jacques, Nonnecke, Preece, and McKerlie (1993) as yardsticks for evaluation. To test the impact and effect, we regularly asked students to review the tutorial. Additionally, during each iteration, we personally critiqued the presentation of the material.

References

POSTER / DEMONSTRATION
Case Studies in Coaching and Facilitating Student Creation of Multimedia

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It will be commonplace for almost all educated people to create multimedia, as well as use multimedia information that others prepare, in their academic and working lives. We present case studies in preparing students:

- Coaching in-service and pre-service teachers and educational technologists to facilitate K-12 students in creating multimedia projects
- Teaching multimedia through distance learning
- Enhancing traditional computer science and business courses
- Enhancing general undergraduate college students' computer literacy with meaningful multimedia experiences
- Integration into standard English course curriculum
Towards Adaptive Multimedia Systems

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System users can differ in their ability to learn, their knowledge on the subject covered, their different background, and most important, their different goals and expectations. This justifies the need for a different level of adaptation. We define the level of adaptation as a function of the user preferences and the level of interaction. “User preferences” refers to the number and depth of the questions that the system is asking the user. “Level of interaction” refers to the “when” and “how many times” the system is asking the user’s preferences. Multimedia systems can be categorised in three categories based on their level of adaptation. In the stereotype model there is one or many predefined navigation paths. In the selective model there is an introductory session where the user is identified. The adaptive model uses information about the user in order to prioritise the information that the user is most interested at.
A Demonstration of Multimedia Teaching Packages at the Australian National University

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The Multimedia Interactive Learning Laboratory (MILL) is an initiative established at the Australian National University to provide an opportunity for educators to take advantage of interactive multimedia techniques in their teaching. The presentation will showcase the wide variety of projects in which the MILL has been involved.

Initially based in the Division of Biochemistry and Molecular Biology, the MILL has expanded its scope to encompass educational software in forestry, linguistics, genetics and Thai language. The group is developing a touring interactive exhibition as part of the university's 50th anniversary celebrations.

Demonstrations of such projects will be used to illustrate the experiences of the team from initial contact to final product. Presenters will discuss concept brief, funding, legal and copyright issues, software and graphic development and software implementation.
Courseware for Undergraduate Technical Students on Superconducting Accelerator Magnets: An Interdisciplinary Application

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The 5 units of this interactive multimedia courseware on the development of superconducting accelerator magnets will provide an excellent example of an interdisciplinary technical project, using skills of physics (materials science, electricity and magnetism, particle dynamics), engineering (mechanical, electrical, and cryogenics), and computer programming (control systems and data analysis). Prototype versions of Units 1 and 3 are available now. Unit 1 on "Accelerators and Magnets" explains the role of magnets and all stages of magnet construction, using animations and video clips. Unit 3 on "Magnetic Design" develops the analytical description of magnetic fields and includes an interactive procedure that allows users to vary basic magnet design parameters and see the effects on magnetic field quality.
During the academic year 1994-95, a dozen of graduate students worked in the development of HTML materials about educational contents, in the University of Barcelona. The main aim of this work was to study the design of contents and structure of this kind of documents.

The posterior discussion took to several points:
- They were not computer people
- The programmes for preparing html pages required a deep understanding of tags and structure.
- These programmes were in English, and some people had serious problems with this.
- Some programmes did not facilitate the use of national characters as accents,...
- An only document had to be prepared in separated pages html.
- Some programmes and filters seem to consider that the conception, structure and development of a document in the Web was similar to a letter to print.

The key aspects of Basile are related to the specific problems found in the group but the programme intend to answer to different needs over the wide world.
Uses of Student Modeling in an Intelligent, Multimedia, Mathematics Tutor

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The domain of remedial mathematics is an important topic in community and four year colleges’ mathematics curriculum. Students need basic arithmetic skills to continue their coursework, and because they retain fragments of knowledge from previous exposure to the material, often have underlying misconceptions. These factors, combined with the relatively narrow scope of basic arithmetic, make this an excellent domain for the development of an intelligent tutoring system. We have constructed a mathematics tutor that is based around two primary components: 1. A strong student model that is used for topic selection, problem generation, and hint selection. 2. The use of animations and “virtual manipulatives” to demonstrate to students how components of procedural skills tie together, and to show the underlying conceptual picture of what is actually occurring when an arithmetic transformation is applied. The tutor has currently been deployed, and we are conducting an evaluation to determine the effectiveness of its instruction.
Cognitive Issues in the Design of Windowing Environments

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Multimedia applications encourage users to manipulate the screen image and the information presented. This is particularly true with regard to windows. Windows refer to a number of rectangular screen objects that fulfill information access and management functions which define, for the user, the interrelationship of the various views of data. The metaphorical nature of windows enables users to semantically organize information in a manner that is spatially represented by the window arrangement. The ability of a feature of an technology to model or supplant human cognitive activities has been recognized. Salomon (1972, 1979) suggested that some of the symbolic features of instruction, under some conditions, can be internalized by learners and serve as “tools of mental representation”. Windowing environments appear to represent one such collection of tools and may be used under program or user control to model or activate specific cognitive skills critical to encoding information in memory.
Sharing Parts of Forty Professional Lives with Television

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The content of the television distance education course Management of software projects is described. It is a mandatory course of the undergraduate program of computer science from University Laval. Thirteen television programs are used to show the workplace reality. We first summarize the result of the needs analysis that drives us to design and develop this kind of distance learning material. Then we give an idea of the knowledge that students must acquire. Learning objectives and instructional theories used are detailed. The objectives are based on the professional tasks the students will have to perform when they will be on the workplace. The teaching and learning material is: a study guide, a mandatory book, 13 television programs, exercises, phone and email assistance. During the presentation we show how the use of television programs allows the sharing of parts of the professional lives of forty experienced managers in software projects.
Science Technology Entry Program: Integrating Technology into a Cross Curricula Design

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Abstract: The Science Technology Entry Program provides math and science for inner city youth around New York State. STEP in Albany, New York is a collaboration between the University at Albany, SUNY, Albany Medical College, and Philip Livingston Middle School. Students meet during the week to learn about math, science genetics, graphing calculators, multimedia technology, and the Internet. Students meet guest speakers and attend field trips in the related fields. The students are developing newsletters, multimedia products, and creating World Wide Web site about the program. The program is exploring ways to integrate technology into cross curricula design areas of math, science, English, technology, and social studies.
At the Kirksville College of Osteopathic Medicine (KCOM) third- and fourth-year medical students complete clinical training away from the main campus at regional training sites composed of numerous community hospitals and ambulatory clinics. The geographic distribution of our students presents significant problems in ensuring equivalent experiences for students at different sites. To address this problem, the Kirksville College of Osteopathic Medicine has developed a computer-based clinical log program to track the clinical experiences of students away from the main campus. The log program allows students to summarize clinical encounters and procedures and transmit reports to a dedicated PowerTalk Mailbox. A log management program has also been developed that allows the data to be downloaded into an academic database for review. Utilization of the system has proven to be efficient and has saved significant amounts of time previously used in managing the data.
The Developing, Testing and Rewriting of the Multi-Media Royal New
Zealand Ballet Case Study in Strategic Marketing

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Abstract: Case studies form an integral part of most marketing courses (see, for example Kotler and Armstrong 1994; Cravens and Lamb 1993; and Jain 1993). A prototype was created with the following design principle: We wanted a free-form approach where there were few constraints on what direction a student travelled through the courseware. We tested the case study on a class of final year marketing students. The results from the questionnaire showed that while they liked the idea of the computerised-case study, many of our original assumptions were not entirely accurate.

So we are now investigating the use of a “real” office environment where the information that executives use to make decisions comes in many forms, eg. reports, memos, telephone calls, faxes etc. As a result, the case became based around an office metaphor. The purposes of our demonstration will be to; (1) Discuss the present and the next stage of development, in light of the feedback; 2) Discuss some lessons learned in terms of developing Multi-Media based case studies.
Application of Software to Enhance Listening and Reading Competence in French

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Écoutons! Lisons! et Écrivons! is a software package designed primarily to enhance listening and reading abilities in French, with some attention given to writing. It is geared to first year university students of French as a second language who have a limited background in French. One of the software's main features is that it includes a variety of activities which appeal to both the visual and auditory modes of learning and which can be done independently in the multimedia lab, thereby leaving class time free for the development of oral and written communication.

The courseware was developed for the Macintosh platform and is available on CD-ROM. Dialogues and reading texts have been recorded using the voices of native speakers; students listen and read the texts before proceeding to the exercises. Audio and colorful visual prompts help to facilitate understanding of the texts and the vocabulary. Furthermore, a system which monitors students' progress is built into the program. After having completed the assigned work, students can print a summary result which they then hand in to their instructor.
This paper reports the development of a multimedia aiming to teach about food ingestion in the context of general management of patients with chronic renal failure. This technology will be tested in the self-learning process of the target population through the installation of kiosks.

The software Nutritional Orientation of Patients with Chronic Renal Failure emphasizes the importance of learning about food patients can have, may have and can not have in their diet. It was developed by an interdisciplinary team and brought benefits for the specialist and for the patients.

If this strategy proves efficient medical information should be a truly entertainment.
Piggy in NumberLand: A Multimedia Tool for Numerical Concept and Skill Development with Children Aged 4-8

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Piggy In NumberLand is an interactive 3-D computer-animated CD-ROM project designed to supplement teachers and parents in teaching kindergarten children numerical concepts and skills. A series of games and activities is carefully coordinated and arranged in a toy factory, where the child can navigate and explore, accompanied by 3-D animated playmates who create an enjoyable social atmosphere. The interface is intuitive and no reading is required. The number concepts are presented in a progression spanning the games and activities, and include basic numbering, counting, greater/less than, addition, subtraction, single-digit number facts, place value, and base 10 concept. The design of the games is based on principles drawn from learning, cognitive psychology and cognitive development research. During development, various versions of the games were tested in local kindergartens. Results showed that children who played each game for one 20 minute session significantly improved more in their numerical knowledge than those in a control group.
Designing the Structure of a Hypermedia Package

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Any hypermedia package needs to have a structure to organize the information. The four major types of structure are linear, hierarchy, network, and combination structures. When instructional designers choose a structure, they will consider the following factors: instructional methods, learner style, learner background, the content of the learning, and the learning outcomes.

The instructional methods are didactic method, socratic method, inquiry method, and discovery method. Since the didactic method and socratic method are controlled by the software, instructional designers may structure the package into a linear or hierarchy structure. Since the inquiry and discovery methods are controlled by the students, the network and combination structures may be more appropriate. Due to learner style and learner background, the learner may prefer one structure over the other. Learning content may fit well for one structure rather than others. Learning outcomes may also determine the type(s) of structure available for the learners.
A widely held belief is that self-monitoring and self-management are important behaviors in successfully treating patients with asthma. Interactive multimedia can provide individualized education, document knowledge acquisition and facilitate behavior change. This presentation reports the use of interactive multimedia technology in educating patients about asthma, and providing more efficient and individualized asthma management systems in clinical settings. The Asthma Files, an interactive multimedia program, features two components: (1) acquisition of patient-specific data for use in making the delivered education truly patient-specific; (2) an overview of respiratory physiology, asthma pathophysiology, symptoms/signs and treatment strategies. During this presentation, the program The Asthma Files will be demonstrated and the results of the field test will be shared. Future plans for revising the program and conducting research using this program will also be discussed.
Kindergarten Students’ Predictive Ability Using a Science Interactive Videodisc

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Abstract: The purpose of this study was to determine if there were significant differences among Kindergarten students when predicting whether objects would “sink” or “float” using three media: 1. interactive videodisc only, 2. fourteen hands-on objects only, 3. fourteen hands-on objects with the interactive videodisc. HyperStudio was the authoring program. Data were collected in seven Kindergarten classes from two different schools located in urban and suburban settings. The schools serve a variety of economic level families with racial balance similar to that of the area population. Classes were randomly assigned treatment groups. A post test design was used and no significant difference were found.
ESCUELA: Integration of Environments, Inter-personal Space and Shared Workspace

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ESCUELA integrates environments suitable to distinct situations and learning requisites trying to establish a coherent and casual relationship between learning situations and knowledge building. We understand learning situation as a set of activities evolved in time and space within a specific branch of knowledge, in which students from an initial stimulus interact with means that will lead them to the discovery and construction of knowledge.

ESCUELA integrates learning environments that represent the natural complexity relating to contents; give support to a collaborative construction of knowledge; support intentional learning according to both the student and the teacher viewpoint; answer both the development of cognitive structures and the construction of knowledge.

Every interaction is dealt with within a sort of no-man’s land, where basic learning is processed by means of ‘pieces of knowledge’. Thus the solution to problems leads to the generation of new ‘pieces’ of knowledge. The characteristics emphasized for the definition of ESCUELA are: control of the student, representation and construction of knowledge, playful exploration, co-operative learning, local and long-distance communication, and relationship with the resume.
University social science programs typically require completion of a Statistics course, frequently eliciting fear and procrastination in students. We have found a computer assisted learning approach which combines engaging presentation, mastery before proceeding, frequent testing, reduction of time pressure and review as necessary increases understanding and reduces apprehension.

A university-level interactive tutorial for introductory statistics has been in use for two years. Key features include: presenting material in multiple forms; emphasis on the logic of statistics; frequent feedback and evaluation; frequent multiple-choice tests with access to subsequent chapters contingent upon high performance levels; a set order of presentation combined with flexible access to review material; a light style of presentation; test examples drawn from multiple disciplines; network-based delivery, extensive automated record-keeping.

The system allows upper-level students to handle most upkeep and allows professor time to be used for higher-level student interaction than previously possible.
Recently, the CIS Department at Southwest Missouri State University found itself in a unique position to provide cutting-edge education for Missouri IS professionals with in-field employment and a bachelor degree. The means through which this education will be provided is a MS curriculum designed to update the training and experience of candidates by exposing them to state-of-the-art technologies and managerial techniques. The program has two unique aspects. First, it is designed for experienced professionals in the information systems field. It will serve persons with three years minimum work experience in information systems. Second, the program will increase access to persons throughout the state by using computer conferencing to augment concentrated on-campus instruction. Following an intensive two week stay each semester, students will return to their jobs to complete the course at a "distance" with dial-up computer conferencing that uses a computer bulletin board system and/or the World-Wide Web and e-mail.
We developed an internationally authored educational piece for students, teachers, practitioners, and technical staff. Text, slides, radiographs, videos and animations are readily searched, and a preoperative “planning” environment is available. All elements are consolidated on one CD, while enabling software, prepared for both Macintosh and Windows platforms, resides on the users’ hard drive. Text, and most illustrations can be printed for off-screen consumption. In addition to the manifest advantages of the multimedia approach to teaching, we emphasize the importance of teamwork and efficient information transfer amongst the key players during production, including: authors, computer scientists, venture capitalists, and industry. Despite excellent reviews in current trade journals, lack of end-user familiarity remains the main stumbling-block to wider distribution.
A Virtual Reality Environment for Jazz Improvisation

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The design, components, and operation of a system dedicated to the development of students' jazz improvisation skills will be discussed and demonstrated. Off-the-shelf hardware and software have been combined to provide a productive lab environment with several friendly software agents which students use to generate 'virtual' combo groups to improvise with during solo practice. A tool to assist students in the transcription and performance of recorded solos will be demonstrated. Software to aid composition, notation, and lead-sheet production will also be discussed. The perceptions and comments of students and faculty who use this facility will be presented along with a list of the components and materials used in constructing the lab. Also discussed will links in the web to interesting sites associated with jazz education and improvisation.
User-Centered Education: Teaching Computer Graphics for Artists and Designers

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Abstract: This poster/demo describes an approach to instruction in computer technology in the Design Art program at Concordia University. Learning-by-doing is viewed as a collaborative process which gives students a sense of mastery, desire and confidence. Alan Kay’s reinterpretation of Jerome Bruner's identification of a doing mentality, an image mentality, and a symbolic mentality provide a useful way to think about the different stages of learning that take place in the computer lab. Donald Norman’s description of stages of complex learning and advocacy of user-centered design compliments an approach to instruction inspired by Seymour Papert's observation that the computer should be thought of as a material with which one constructs. Learning-by-doing is seen by itself to be inadequate and that selected organized presentation is required. User centered education encourages self directed learning where students discover solutions through self created methods and tools.
Hypertext DataBase Management for the Cognitive Navigation and Creation of New Hypertext

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This project develops a prototype of hyper-environment capable of reuse already edited materials. Emphasis falls on the teaching strategy employed and on the hypertextual structure which is developed with the aid of specific utilities in Windows environment. This is fundamental in the evaluation on the efficiency of the seminar. In particular we carried out a configuration manager of the hypertext which keeps track of the cognitive links rather than of the physical ones; reducing the overload imposed by an inadequate hypertext. Our product reuses the material original format - sections of books, journals and slides - as well as the existing conceptual links. However, it is always possible to add specifications to the semantic concepts. The configuration management is based on software engineering techniques, optimized for the development of hypertexts. In particular we consider the phase of conceptual analysis for the cognitive content, and the entity relationship diagram for the conceptual network. New hypertextual documents are managed through a simple standard, forced automatically by the same system.
To overcome the excessive costs associated with printing, storage, and distribution of paper documents, Navy Training decided to create and deliver digital files to its shipboard sailors. To avoid future problems caused by ever-changing proprietary software, the Navy chose to use Standard Generalized Markup Language (SGML) as its primary development tool. SGML requires the use of a Document Type Definition (DTD) and a viewer stylesheet. The Navy has been able to create a 24 volume set of electronic textbooks on basic electricity and electronics. These digital textbooks contain audio, video, animation and still text, all easy to revise/update, and deliverable via CD-ROM, real-time, and will produce a postscript output of the text and graphics for printing of a hard copy.
Electronic media in distributed computing environments that are not maintained become unusable, so electronic publishing projects exist for a long time rather than for a short-term production cycle. Meta-Media Management is a project management model for long term electronic publishing based on a research study of electronic publishing projects in distributed computing environments which continued for 10 or more years [Hopper, 93]. The model is structured around the following four types of critical tasks: design tasks focused on descriptive factors; development tasks focused on dynamics and change; delivery tasks focused on regulation and maintenance; and recovery tasks focused on decline and breakdown. The four task types do not reflect stages through which a project evolves, but rather ongoing activity that needs to be continuously repeated.

References

The Structure of Human Memory and Potential Impact of Multimedia on Learning

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This research review tackles the issue of the effect of instructional multimedia from the perspective of the cognitive neurosciences. Ample research evidence in that field has shown that our working memory consists of separate systems for processing audio, visual, and spatial information. Studies of imagery have shown that information seems to be stored as differing formats in corresponding areas in the brain rather than in a single format such as propositions. This multiple coding system makes it possible for our brain to simultaneously process differing information formats and eventually store them in their proper places for retrieval. It is assumed that these differing information formats will interact with one another through the pathways and synapses of the central nervous system, thus creating a network of knowledge. Through interaction with multimedia materials, the learner can thus take in more information and create more complex networks of knowledge than he or she could from a single medium source. This review of 24 experimental studies on the effects of multimedia instruction reveals that its effects are on the whole quite positive. Based on this evidence, it is concluded that the use of interactive multimedia instruction should have positive effects on learning. (The review contains 55 references)
Oz-TeacherNet: Teachers Helping Teachers for Professional Development

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Oz-TeacherNet is an electronic community based on a conception of professional development which is teacher-centred, dynamic, interactive, and embedded in the particular contexts in which teachers conduct their daily business. Teachers are encouraged to participate in discussion lists, on-line curriculum projects, and electronic publishing as well as being able to access a range of training and curriculum materials. Oz-TeacherNet is also a gateway to the resources and activities of teacher professional organisations and employing authorities.

A number of research projects are being conducted in conjunction with the project and these focus on the contribution that involvement in Oz-TeacherNet activities can make to teacher professional development. In particular, a model for conducting on-line curriculum projects has been developed and is being evaluated during 1996. The process of designing, developing, and implementing an electronic community for K-12 teachers is also the subject of a major study.
Multimedia Training Packages for the Mining Industry

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The coal industry is a major export earner for Australia. The industry requires trained personnel to maintain high production rates. One of the largest problems of the industry is that operators do not receive educationally sound, consistent and standardised training materials for areas such as safety and the operation of equipment. This creates problems for the safe and effective operation of a mine.

The Interactive Multimedia Unit addressed this training problem by developing nine instructional packages for Curragh Queensland Mining Limited and VETEC (Vocational Education, Training and Employment Commission). These computer programs introduce miners to different mining vehicles including: cranes, front-end loaders, haulers, graders, forklifts, and drill rigs. There is also an environment package which examines mine conservation practices.

Multimedia was chosen as the medium for this training package because it allows for the supply of consistent information and the standardisation of training, which solves a major problem in the training of mine operators. The packages also cater for shift workers as they provide a self-instructional, self-paced training medium.
Integrating Computer Algebra System in the Teaching of Trigonometry

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This paper describes an alternative, inductive approach to the teaching of trigonometric identities at the secondary school level using the software Maple. Currently the teaching of trigonometric identities is mainly done through the deductive approach. A crucial gap for student understanding is the lack of visual representation. This gap can be effectively bridged with the help of a Computer Algebra System (CAS) like Maple.

The paper demonstrates how a CAS may provide an interactive environment for students’ exploration and understanding of trigonometric identities, by building on their knowledge of and experience in function manipulation. Various identities, from the simpler Pythagorean and cofunction identities to those involving sum and product of trigonometric functions can be effectively demonstrated using a visual-transformational approach. CAS plays the role of visual manipulatives, and is found to be useful in helping students see how mathematical concepts are evolved and developed.
A Qualitative Case for Increasing Technology in Teacher Education

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Overview

Teacher attitudes influence the use of technologies in education. This study is an effort to ascertain the attitudes of education majors towards technology. Twenty-three education majors participated in semi-structured interviews. The interviews were examined and five themes emerged:

1) Fear
2) Confusion/frustration
3) Lack of experience/knowledge
4) Recognizing appeal and potential
5) Refusing technology

A lack of computer experience and knowledge has lead these perspective teachers to become confused and afraid of technology. The data indicate that the rejection of computers will continue until preservice teachers are forced to utilize them. This implies that if a technological revolution is to occur within education it must be initiated at the teacher education level.
This session examines the principles underlying the design and production of a CAL multimedia-based package teaching linguistic awareness to students. The constructivist view of learning is adopted. Users are treated as active learners who approach knowledge on the basis of meaning-making. The main challenge to the construction of a CAL package is how to capture the dynamic meaning-making process in the powerful minds of learners. In addition to the adoption of principles of learning and interaction, CAL designers need to develop some effective strategies to motivate the learners in the use of the software. Our project considers the following strategies:

- Using humour, problem-solving, story-telling, quiz to introduce learners to make sense of some linguistic knowledge.
- Using the Internet and multimedia to provide motivation to learners to explore issues interactively.
Ophthalmology Educational Program

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Abstract: Presently, the school’s concern is directed to a more limited conception of teaching: the allocation of teachers, physical space accommodation, number of students per class, curricula, timetable, etc. To minimize the learning problems, related to the presented teaching method, we developed the Educational Program on Ophthalmology, that offers an interactive and self-controlled way of learning, through the multimedia and hypertext (hypermedia) resources to the students. The themes used to build the program were: Anatomy (studies of the main ocular structures), Examination (explanation of diagnostic methods for ocular evaluation), Ocular optic (application of the optical physics) and Pathologies (physiopathology, diagnostic and treatment of the main ocular diseases). The software has 200 images (pictures and photos), 40 minutes of digitized voice, 50 minutes of video animations and more than 200 hotwords. The first evaluation demonstrated a great interest from the medical graduated students, who feel motivated with the utilization of the software.
Integration of Device Control in an Interactive Learning Environment

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We have developed ROBOTEACH an interactive learning environment which cooperates with learners and teacher in a context of technology learning [Leroux 1992]. ROBOTEACH is interfaced with pedagogical micro-robots. These devices have different roles: revealing of new notions, revealing of knowledge and know-how needs. Above all they facilitate the shift between levels in abstraction and reveal the dysfunctions in the virtual world. When the learners work with a learning software, they work in an artificial virtual world. They compare their "virtual work" on the real world through experiments with micro-robots. The dysfunctions of the device is the result of dysfunction of the virtual device.

Multimedia for Marketing a University degree in Information Systems

Staff in the Department of Information Systems, Central Queensland University have organised the development of a multimedia CD ROM to market the Bachelor of Business (Information Systems) Degree. This CD ROM was designed to appeal to high school students, aged 15 to 17.

The content of this package includes:

- information on the degree,
- staff in the Information Systems department,
- responses to common questions about the degree,
- how to apply for entry to the degree program,
- career options available after graduation, and
- information on the university in general.

Features that are incorporated in the multimedia package include, still pictures, music and morphing of digital video images of the Information Systems staff. The CD ROM is both IBM and Macintosh compatible.

The development of this package was a team effort involving members of the Faculty of Business Information Systems Staff and the University's Interactive Multimedia Unit.

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This screen allows the user to find out more about Central Queensland University. The user clicks on an option to play a video.
This screen displays eight commonly asked questions about our degree programme. They are answered using audio files accompanied by still graphics.

About CQU - Why IS - IS Staff - Course - Careers - What now
A very popular feature of this screen is the morphing of the staff images. Digital videos are used to introduce the staff, the Dean and the Information Systems degree.
Videos describe the units that are offered in the degree programme.
The three main career options are described using audio and graphic images.
The students are told how to apply for enrolment into the degree programme.
New Communication Technologies and Social Movements: Can computer networks function as social networks?

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Abstract: The goal of this paper is to contribute to the clarification of the role new communication technologies play in contemporary social movements and social change by addressing case studies of social activists’ use of new communication technologies in relation to social network theory. It is argued that, while social network theory is unable to provide full answer to all of the issues raised herein, it does enjoy the greatest isomorphic fit with observed computer network activity, and thereby provides the best working template for future research on the relation between new communication technologies and contemporary social movements.

Social scientists (McAdam, McCarthy, & Zald, 1988) have observed how essential it is for social movement activists to exploit communication resources and develop effective social networks (Snow, Zurcher Jr., & Ekland-Olson, 1980; McAdam & Paulsen, 1993; Gould, 1991) in order to achieve their goals. On such views, communication must be able to “generate sympathy among bystanders,” while maintaining “legitimacy and efficacy” among movement participants (McAdam, et al., 1988). Social movement activists have long depended on the use of the mass media to achieve such goals and get messages to potential movement participants (Morris, 1984). However, this dependency is problematic. While disseminating information about grievances via the traditional mass media can be a relatively inexpensive means of reaching a very broad audience and may contribute to significant macro dimensions of society (i.e., strengthening perceptions of social stability or unrest, see Katz, Blumer, & Gurevitch, 1974), the demands of contemporary news agencies often force activists to resort to radical behavior to get media attention (Oliver, 1989), put the accurate dissemination of messages at risk (Comber & Mayne, 1986), and may not significantly contribute to the creation and development of significant micro dimensions of society such as the creation and maintenance of social networks and collective identity. Further, a significant amount of research concerned with the persuasive effects of traditional mass communication technologies suggests that the transmission of would-be persuasive messages via such technologies has at best only a moderate influence on target attitudes (McGuire, 1985, 1986). Thus, one might expect that the development and wide-spread diffusion of new communication technologies which promise greater message control, enhanced persuasive potential, and the capacity to significantly contribute to the building and maintenance of social networks and collective identity, would herald an exciting and significant event for social movement activists. Is it?

The fact that many social movement activists have become sophisticated computer network users who take advantage of personal computing technology, telephone lines, and existing satellite link-ups to monitor government agencies, collect and distribute information on a wide range of socially significant topics, and organize activities, has lead some observers (McCullogh, 1991; Signorile, 1993; Myers, 1994 ) to suggest that computer networks are an effective means for building and maintaining social networks, collective identities, collective behavior, and social movements. However, while it is recognized that, “any technology that changes the collective character of a movement has important ramifications for the process and effect of social movements” (Myers, 1994, p.252); that new communication technologies can be effectively utilized to further the interests of special interest groups (McCullogh, 1991); and that the range of activity on computer networks provides ample opportunity to study several practical and theoretical issues regarding social movements (Signorile, 1993; Myers, 1994), the systematic study of how computer networks contribute to the creation and maintenance of collective identities, social networks, collective behavior and social movements is still in its infancy. Little extant research addresses the theoretical and practical questions concerned with how and when, if at all, the use of computer networks contribute to such goals. Do social movement leaders and followers socially construct durable and meaningful interpersonal relations on computer networks? If so, how does social influence operate on computer networks and under what conditions can computer networks create enough
collective identity among members to sustain collective action in actual or virtual social space? Answers to these and other important questions about social movement activists’ use of computer networks remain unclear.

This paper contributes to the clarification of the roles new communication technologies play in contemporary social movements. It begins with a review of some of the most recent work done by scholars concerned with the study of the micro social dimensions of new communication technologies in relation to social movement theory. This discussion is then extended to include a short survey of related micro social dimensions that have thus far been overlooked. These dimensions combined are then addressed in reference to social network theory. It is argued that social network theory enjoys the greatest isomorphic fit with observed computer network activity, and thereby provides the best working template for future research on the relation between new communication technologies and contemporary social movements.

The Pragmatics of Internet Activism

To date, studies of social movement activists’ actual use of computer networks have focused on three major areas: 1) activists’ use of electronic mail systems (email); 2) activists’ subscription to on-line services; and 3) activists’ interaction on topical computer networks. A fourth use, the creation of “homepages” -- personalized computer network bulletin boards which can support full-color graphic interfaces and incorporate “hyperlinks” (a computer programming routine that allows users to access related data banks once connected to a homepage) -- is perhaps understandably understudied as it has only become feasible with the relatively recent development of the World Wide Web (W3) and related Netscape computer software. However, as is discussed below, homepages appear to significantly enhance computer network users’ information search, browse, and transfer capabilities, and may have profound effects on social activists’ ability to create and maintain social networks, collective identities, collective behaviors, and social movements.

Email, subscription services, and topical computer networks

Myers (19994) describes how social movement activists use email systems to send and receive information from friends, colleagues, and other activists from all over the world, who, in turn, can forward received mail to other email addresses. By doing so, exact copies of files are disseminated “to thousands of like-minded computer users in a very short time” (Myers, 1994, p.251). The result is widespread dissemination of information without the misinformation that is typically a by-product of ‘pass-along’ methods of data distribution (Turner & Killian, 1972). As social movement activists’ rely on informal networks to distribute information about the grievances and activities of the movement, activists’ effective use of email has been heralded as a substantial advance in social movement communication procedures. Such advances are perhaps particularly evident in the case of the utilization of subscription services.

Using subscription services, individual activists, or the organizations to which they belong, set up a sort of “clearing house” for information related to particular movements. Computer network users ‘subscribe’ to such services, “which upon receipt of a certain amount of information sends an E-mail message to all its subscribers containing all the information it has received since the last mailing” (Myers, 1994, p.252). Using such services, activists are able to transmit data to thousands of other activists without needing to know each of the others’ individual email addresses. In addition, once a subscriber receives subscription data, she can forward the information to non-subscribed addresses using regular email and thereby widen the breadth and increase the depth of information distribution exponentially.

Myers (1994) also describes how topical computer networks, a significant number of which cater specifically to the concerns of social movement activists (i.e., Peacenet and Econet), provide an additional forum for activists to share and debate information concerning particular causes, advertise upcoming activities, solicit support, and provide news and updates about ongoing social movement organizations.

Referring to two separate Peacenet conferences, one dedicated to the pursuit of gay and lesbian rights, and the other to the ongoing efforts of activists involved with Amnesty International, Myers (1994) describes how such topical computer networks were used to “generate sympathy among bystanders” by encouraging participation from what Oliver (1989) refers to as “third party audiences,” and contribute to the maintenance of legitimacy and efficacy among participants by tracking activists efforts (i.e., letter writing campaigns) and reporting movement successes. Direct action in support of a cause can be the result. Given this is the case, the development and use of “homepages” should only increase the probability of such direct actions by sympathetic bystanders and interested others.

In fact, World Wide Web (W3) and Netscape services and software have changed the very nature of computer-mediated communication between people and organizations by facilitating the transmission of text,
still-images, and full-motion video and providing the means by which individual users and organizations can set-up and maintain permanent Internet ‘addresses’ known as homepages. These hyperlinked documents allow network users to enter social movement organizations’ “websites” any time of the day, link to related documents referred to at one site but stored at another, access files containing glossaries of important terms related to the issues at hand, contribute comments and suggestions, ask questions about the organization and its cause, and receive immediate feedback based on those questions from a preprogrammed “frequently asked questions” (FAQs) file or on-line respondent. In addition, since the authors of homepages retain full control over its design and content, any particular website can include anything from text and visuals of a movement’s history to electronic news coverage of the organization’s latest activities. To assist activists further, the network ‘address’ of the organization’s homepage can be published in hard copy, sent out across computer networks, and referenced via hyperlinks established on other sites. Homepages may even provide a cheap and efficient alternative to creating and maintaining newsletters. Also, because W3 and Netscape software facilitate computer network use by providing user friendly search and work environments, using computer networks is made more attractive to people with only limited computer training or experience. For example, most routine Netscape functions can be initiated and carried out by simply pointing and clicking the computer cursor indicator device (i.e., the ‘mouse’) on pre-programmed iconographic buttons. Since, “not enough time,” is one of the major reasons social movement sympathizers posit for remaining on the sidelines and not getting involved in social movement activities (Snow, et al., 1980), such simplified computer network operations could profoundly effect social movement participation by allowing an individual to take direct action while investing only small amounts of time and energy.

Other distinctive characteristics of new communication technologies

There are other distinguishing features of new communication technologies, such as simultaneous multichannel communication, that not only facilitate the transmission of information but may also enhance the persuasiveness of the information transferred and facilitate community building. Katz et al. (1974) found that communication channels can be differentiated by the needs that they are typically perceived to meet. For instance, newspapers were perceived as helpful in providing information about and building confidence in society, overcoming loneliness, and in strengthening social stability. Television, on the other hand, was viewed as helpful for killing time, spending time with family, and generating festive moods. These so-called “normative images” of the media appear to be influenced by the societal structure and media system in which they are found (Elliot & Quattlebaum, 1979; Kippex & Murray, 1980), and the social presence, or perceived personalness, of the communication channel itself (Williams, Phillips, & Lum, 1985; Williams, Rice, & Rogers, 1988).

Social presence has traditionally been defined as the feeling that communication exchanges are sociable, warm, personal, sensitive, and active (Short, Williams, & Christie, 1976). However, when concerned with communication channel attributes, social presence is perhaps best conceptualized as a perceptual dimension of users which can be significantly influenced by communication goals (Acker & Levitt, 1987; Short et al., 1976). Thus, when a particular channel is perceived as capable of satisfying more personal goals, users should rate it as having a higher social presence. On this view, communication technologies that utilize the most communication channels simultaneously (i.e., interactive computer networks) should be perceived as being capable of fulfilling the most personal communication needs and achieve the highest ratings in social presence. New media, then should have the best chance of facilitating the creation and maintenance of social networks, collective identities, collective behaviors and social movements.

New Media, Collective Identity, and Social Influence

A more comprehensive understanding of the role of computer networks in social movements is furthered by an appreciation of the characteristics of typical computer network users and the virtual spaces in which they interact. For example, one point often mentioned in the literature on computer networks is the fact that, despite the incredibly long reach of computer networks, the population of computer users makes up only a small percentage of the general population. This fact is not difficult to understand given that the initial costs of securing and subsequently maintaining access to computer networks alone effectively disenfranchises many potential computer network users. Yet, the decreasing costs of start-up, the development of increasingly user-friendly interfaces, the use of natural-language programming, and increasing public access to computers all contribute to eventually overcoming the elite-user problem. However, the elite user may not be the most serious obstacle to the development of diverse computer communities. Ironically, it appears that the shear abundance of
Typical users of the Internet follow very narrow pathways through the enormous amount of information available to them (Myers, 1994). Such use patterns have inspired some researchers to question the appropriateness of using the word “community” in attempts to describe virtual social networks. Indeed, since most users seldom interact with others from different political, economic, and ethnic backgrounds, one may ask, “Can virtual social networks ever truly function as real social networks?” And the answer, according to several well respected researchers of such issues (e.g., Epstein, 1973; Habermas, 1989; Parenti, 1983) is, “Yes, in this sense, they can.”

Members of virtual social networks, like their counterparts in real social networks, can be found gossiping, complaining, comforting and harassing each other, beginning and ending love affairs, praying for one another’s sick, and generally communicating as members of a small community (Myers, 1994). However, as one commentator reminds us, “a lot is still missing from the communities of cyberspace, whether they be places like the WELL [Whole Earth ‘Lectronic Link], the fractious news groups of USENET, the silent ‘auditoriums’ of America Online, or even enclaves on the promising World Wide Web” (Barlow, 1995, p.54).

Members of cyber communities lack physical presence in that most computer terminals render the user deaf, dumb and blind, denies each the ability to touch or smell another, and thereby forbids many of the kinds of interactions that make relations between people “feel real.” This is significant in light of the fact that the physical density of an aggrieved population has been found to facilitate the growth of collective behavior (McAdam et al., 1988; Morris, 1984).

Density and homogeneity in “close-knit” and “loose-knit” groups

Early researchers found that the physical density of social network effected peoples’ perceptions of what was “normal,” and the way in which people determined what was normal (e.g., Bott, 1957; Lazarsfeld et al., 1948). In short, these researchers found that people in “close-knit” networks behave differently than people in “loose-knit” networks. According to Bott (1971), people in real “close-knit” networks tend to find little variation in social norms and have less difficulty stating behavioral norms explicitly. They are also more likely to use their networks as reference groups, and are more likely "to be made aware that their social norms are not norms of common consent" (Bott, 1971, p.213). In addition, Bott observed little ambiguity in close-knit groups about what is expected of members; if a group member deviated from the norm, the other group members let it be known that the behavior was unacceptable. On the other hand, people in “loose-knit” networks tended to be exposed to many different standards of behavior and attitude and had a considerable range of potential reference groups to choose from. Thus, loose-knit group members had "considerable opportunity to treat personal norms as social norms [and] assert that the standards they follow are those that are current in their social circle or in some similar reference group” (p.214). As a result, loose-knit group members are less likely to be influenced by normative behavior.

Laumann’s (1973) analysis supported Bott’s in that he also found that certain characteristics of social networks have significant effects on network members’ attitudes and behaviors. Referring to loose-knit networks as “radial”, and close-knit networks as “interlocking”, Laumann noted that “interlocking networks serve as more effective social anchors for an individual's attitudes, leading to more well crystallized attitudes on various issues characteristic of given social positions” (p.126). He suspected, however, that whether or not individuals use their social network as anchors for attitudes depended on the attitudes in question. For example, Laumann reasoned that when the attitude in question concerned moral and religious issues, one could expect the attitudes of ethno-religious group members to be significantly homogeneous. Likewise, when the attitude in question concerned work-related issues, one could expect the attitudes of workers of equal occupational status to be significantly homogeneous. In accordance with this reasoning, Laumann hypothesized that different types of group homogeneity would affect different types of attitudes. Laumann went on to show that not only did homogeneous networks ‘foster and sustain more `extreme', clear cut and consistent attitudes than heterogeneous groups” (Laumann, 1973, p.98), but also that close-knit, or interlocking, homogeneous groups were more intolerant of group outsiders than loose-knit, or radial, heterogeneous groups.

Extending Laumann's analysis, Bienenstock, Bonacich, and Oliver (1990), tested and found significant support for the hypotheses that increased racial, religious and educational group density and homogeneity would intensify characteristic intergroup differences in attitudes regarding related social and political issues. However, the authors did not offer a clear explanation of why this may be so. For this, Turner, Oakes, Haslam, and McGarty’s (1994) research concerning self-categorization theory is more helpful.

Self-categorization theory makes a basic distinction between personal and social identity as different levels of self-categorization. As such, social or collective identity is primarily a process of the emergent...
properties of group processes which can shift an individual’s self-perception from personal to social identity. Because these shifts vary with the social context, advocates of self-categorization theory argue that, “self-categorizing is inherently variable, fluid, and context dependent, as self-categories are social comparative and are always relative to a frame of reference” (Turner, et al., 1994, p. 454). On this view, the collective self arises as part of a normal variation in how people categorize themselves.

Such considerations raise a number of important questions about computer network users’ ability to facilitate the creation and maintenance of social networks, collective identities, collective behavior, and social movements. For example, do different computer networks and computer conferences engender different perceptions of social network density? And, do these perceptions differ from those engendered by physical density?

There is ample evidence that suggests that computer network participants who subscribe to certain conferences and participate in them regularly, develop a sense of having membership in a “close-knit” group (i.e., the men’s movement as described in Myers, 1994, p.256). If so, “close-knit” computer network users may in fact be more susceptible to being influenced to act in accordance with the norms of the groups to which they subscribe than would casual conference participants or members of “loose-knit” virtual social networks. On this view, preliminary case studies of differently structured virtual social networks could be used to examine many of the theoretical issues reviewed above while providing a basis for further research and discussion concerning computer networks capacity to function as social networks. Case studies are particularly useful in this regard as they typically focus on relatively holistic understandings of cultural systems of action and are routinely used in social scientific studies. With this in mind, the following section presents the first in a planned series of preliminary case studies of the related dynamics of virtual social networks: the so-called “Internet community’s” recent defeat of an anti-freedom of information act (FOIA) provision in the federal Paperwork Reduction Act.

The “West Provision”: A case

On Monday, February 6, 1995, Congress introduced legislation (HR 830) as part of the House Republican’s “Contract for America.” HR 830 contained several provisions that would curtail public access to government information, including a special interest provision inserted on behalf of West Publishing. By Friday, February 10, Congress had held one hearing and two mark-up sessions and reported the bill out of the full committee for floor action. However, between Monday and Friday, messages circulated on the Internet generated broad based opposition to the provision, which inspired heated debates in Congress, and the “West Provision” in HR 830 was struck from the bill. As a major participant in the virtual protest noted, “Never before had the large data vendors (i.e., West Publishing) lost such a clear vote to the right-to-know community, and the fact that it happened before a Republican controlled committee illustrates how much this debate has changed in the last four years” (love@essential.org., February 14, 1995).

In the aftermath, a detailed description of the so-called ‘right-to-know’ community’s computer network activities prior to the defeat of the amendment was distributed on TAP-INFO, a free Internet distribution list created by Ralph Nadar. According to the TAP-INFO posting, the protest began when a few TAP-INFO users learned that the bill would be introduced in Congress and issued detailed “alerts” across the Internet. When alerted computer network users expressed difficulties in finding copies of the legislation, TAP-INFO users found a draft paper copy of it and sent it out across the Internet as well. Meanwhile, TAP-INFO posted several Internet updates on the situation, and Congress began to receive email messages, telephone calls and faxes from constituents, businesses and professional groups who opposed it. In addition, representatives of the American Library Association responded to the TAP-INFO alerts by issuing their own Internet notes about the provision, and hundreds of individual activists wrote or forwarded messages about the controversy to different Internet distribution lists.

By the morning of February 9, it was clear the “right-to-know community” campaign was having an impact on the fate of the pending bill. Congressional staffers reported that they were hearing from an “outraged public” over the provision, and some of the relevant Congressional committee members were openly reconsidering the language used in the bill. Then, on the night of February 9, TAP-INFO representatives learned that the disputed provision had been thrown out of the proposed bill, and that nothing would be done to impact the FOIA.

On closer analysis, it is clear that the computer network activities of the apparently close-knit TAP-INFO ‘right-to-know’ community, the only obviously identified social group referred to in the case above, generated and maintained collective behaviors in much the same ways as one might expect any social network would; formal and informal discussion groups were formed to debate the relative merits of positions taken, members gossiped, complained, comforted and harassed each other, and generally communicated as members of any small community. The lack of physical presence between members did not appear to hinder the creation and
maintenance of perceptions of a collective identity within the groups as “the emergent properties of group processes,” (Turner et al. 1994) effectively shifted individual self-perceptions from the purely personal to the more public and social. In addition, these collective identities tended to become more salient in intergroup contexts. Thus, while future research would certainly help clarify precisely how and when loose-knit virtual social networks become close-knit virtual social networks, what is clear thus far is that the assumption that physical presence is somehow necessary for social networks, collective identities, collective behaviors, and social movements to come into being and maintain should not go unchallenged.

Conclusion

The range of social movement activities on computer networks make such networks a promising local for the examination of a number of different practical and theoretical issues regarding the role of communication in social movements. For example, increased speed of transmission coupled with decreasing costs, interactivity between network users, accuracy of data replication, simultaneous multichannel communication, and improved information presentation formats may have a profound impact on social movement activists’ ability to “generate sympathy among bystanders,” “maintain legitimacy and efficacy” among movement participants, develop meaningful social networks and collective identities, inspire collective behavior, and create and maintain social movements. However, the systematic study of social movement activists’ use of these new communication technologies is only just beginning. Nevertheless, given what is known about the dynamics of social networks, emergent collective identities, and the potential effects of the more perceptual “artificial densities” engendered by particular types of computer network uses, it appears that, while social network theory is unable to provide full answer to all of the issues raised herein, it does enjoy the greatest isomorphic fit with observed computer network activity, and thereby provides the best working template for future research on the relation between new communication technologies and contemporary social movements.

References


Current data analyses indicate persistent or accelerating rates of HIV infection despite extensive, and expensive, mass-mediated HIV-information campaigns. Yet, failing the availability of a medical cure for the disease, the development of effective communication strategies that will obtain the desired knowledge-based behavioral change is still considered one of the most viable strategies to manage the HIV/AIDS threat. This poster and demonstration presents a research program, complete with theoretical rationale, hypotheses, research and interactive media design and analytical methods, that is intended to further understanding of the potential persuasive effects of interactive media in HIV/AIDS prevention programs. Support for this research provided by a grant from the National Institutes of Health.
The Development of Theory of Music Computer-Based Lessons for Underprepared Students

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The changing nature of the student body at South African Universities has prompted a reassessment of existing teaching methods in some academic departments. Several incoming students to the Music department at Rhodes University do not possess the necessary theory skills required for the further study of music. Many students from highly disadvantaged backgrounds have not been exposed to any form of written music and the need for concentrated basic theory of music instruction is critical.

The lessons are developed using Authorware Professional for Windows version 2.0, an object-oriented authoring tool that facilitates the development of interactive multimedia applications. The challenge facing the developers is to make use of technology in a way that is beneficial rather than daunting to educationally and socially disadvantaged English second language speakers.

The demonstration consists of level one (of five) material at present being piloted at Rhodes University. Each term is explained on introduction beginning with the concept of the stave, treble and bass clef.
Re-Purposing An Instructional Design For A Computer- Based Simulation: A Case Study

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The Business Process Overview course illustrates how an instructional design strategy for a computer-based tactical simulation was re-purposed. Tactical simulations allow participants to interact within a problem in order to develop skills in interpreting problems and finding strategies to arrive at solutions. Re-purposing involves adapting the instruction’s content and strategies for another instructional purpose (Tessmer & Jonassen, 1994). The instructional design for the module was not changed structurally in order to re-purpose it. What did change was both the context and the procedures for using it.

Stevens (1993) states that one of the factors that contributes to the quality and consistency of instruction is the number of different representations available for any instructional concept, procedure, or principle. Re-purposing an instructional design can expand the possible number of representations available in a particular subject area. Re-purposing ensures a higher degree of consistency and quality when a design has been previously used with good results.


Evaluation Of The Effectiveness Of ScreenCam For Teaching

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This presentation consists of an evaluation of the use of "ScreenCam" as a tool for replacing or supporting conventional lectures. "ScreenCam" is an interactive tool that takes advantage of multimedia for creating ad-hoc and formal audio/visual presentations on a PC. It captures screen activity, cursor movements and sound into an integrated file that can be saved and distributed to student groups of all sizes. Using results from an experiment this presentation shall answer the following questions:-

- How effective ScreenCam is as a replacement for conventional lectures?
- How effective ScreenCam is in supporting a lecture by allowing students to review the lecture content after the lecture has been delivered?
This presentation gives an overview of the findings of a panel of artificial intelligence lecturers from the United Kingdom and Ireland. The issues that the panel discussed were:

- what topics should we teach within AI modules of different courses?
- what courses teach AI as a module?
- what are the prerequisites of an AI module?
- what are the best approaches for teaching AI?
- what are the main goals of an AI course?
- what are the recommended reference books for teaching AI?
- what computer aids/computer simulations are available for assisting with teaching AI?
- how do we devise a curriculum for AI?
Applying the Power of Telecommunications to Daily Routine in Medical Education

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Faculty of Basic Medicine (FBM) of Lomonosov Moscow State University (MSU) considers itself as medical scientific and educational establishment which has voluntary accepted a task of adoption and implementation of contemporary achievements in the fields of computer technologies and communications into medical education and clinical practice.

Several projects are running or being launched at the Faculty. One of them is Medical Information Server. The server is going to provide public access to information of interest to physicians, medical institutions professionals and students. Emphasis is made on World Wide Web technologies as most flexible and effective.

FBM won't bear exclusive rights to placing information on the server. Every organization or individual is encouraged to take part in the project.

Another challenging project is telemedicine.

Telemedicine has become one of the leading divisions in contemporary scientific and clinical practice. Faculty of Basic Medicine pays special attention to its role in medical education, particularly in postgraduate education of students and staff of affiliated medical institutions. Within the network of cooperating teaching hospitals and universities, telemedicine link is going to serve as a tool for exchange of challenging cases, teaching expertise, "background" preparation and further exchange of didactic materials as well as for mutual long-distance consultations and lectures for students and teachers. One of the tasks is to make an optimal choice of existing media, including hardware and software, and fill remaining gaps with customized products.
There was a positive correlation ($r=0.42$) between the perceptions of the way in which computers can affect education and the opinions about the specific programs. This indicates those who are positively predisposed towards the introduction of computers would tend to positively evaluate the specific tools like the ones used in the psychology experiment. This is further borne out by the significant ($p<0.05$) relationship between the perceptions of amount of help available for computer assistance and the perception of the instructional value of the specific tutorial. Those who reported that they felt that there was enough help available with the computer activities on the university campus also reported they found that the computer tutorials were easy to use ($r=0.33$). These results suggest that there is a relationship between the way a specific computer aided instruction tool is viewed and the overall attitude towards the use of computers in the educational setting.
We studied students who performed collaborative predict-observe-explain activities with relative motion simulations. Half of the students interacted with numeric velocity data and predicted the speeds of objects. The other half interacted with animated velocity data and predicted the movement direction of objects. Gains on a relative motion diagnostic test followed both conditions. However, case studies revealed evidence for striking individual differences in problem solving. While a number of animation students referred to remembered animations and used mental imagery to solve problems, a number of numeric condition students constructed and used faulty mechanical algorithms. These findings suggest that the structure of the activities performed with computer simulations can greatly impact students’ problem solving and mental model construction.

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CALAT: A Multimedia ITS Integrated on the WWW

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We have proposed CALAT, an intelligent tutoring system (ITS) on the WWW in EDMEDIA95 conference. The system consists of an WWW server integrated with an ITS and WWW clients equipped with a multimedia scene viewer. The CALAT system features the mechanism to identify the user on the client side from the sever side, making it possible to adapt to individuals over the stateless protocol of the WWW.

In this demonstration, new version of CALAT will be exhibited. In addition to the above mentioned functions of the old version, following novel features are devised:

- an interactive simulation facility supported on the network-based server/client system,
- a viewer control mechanism enabling fast system response as well as sophisticated client viewer control on the conventional WWW protocol, and
- an adaptive HTML-based courseware utilizing existing HTML documents as an ITS material.
Brazilian Literary Hypermedia Encyclopedia CD-ROM

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Description

The development of a hypermedia application is not an easy task. It requires many skills: good design, coherent structure, attractive interface, multimedia knowledge.

Our work deals with a lot of aspects involved in the development of an interactive multimedia CD-ROM. To investigate these aspects, we have developed a CD-ROM with Brazilian Literary Information, using a technique we have developed, called HMT (Hypermedia Modeling Technique) [Nemetz et al. 96].

The main purpose of HMT is to avoid the so common problem known as lost in hyper-space. HMT allows designers to build an application with a coherent structure, a consistent interface and a uniform navigation model.

References


Acknowledgements

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Research has shown that computer programming instruction can promote problem-solving skills. With the influx of authoring languages such as HyperCard and HyperStudio, it is questionable whether programming languages have relevancy aside from the primary goal of teaching a learner how to program. The purpose of this study is to evaluate the effects of authoring in a HyperStudio course that incorporates in-depth scripting and HTML programming on students’ problem-solving skills and cognitive levels. Problem-solving skills are being assessed through visual representations of the problem space and cognitive levels are being assessed through written descriptions of the design, implementation, and generalization of features and processes that the students incorporate. Authoring programs such as HyperStudio may be software packages of choice if it is shown that they not only make the software development process easier but that they also increase problem-solving skills and cognitive levels.
Educational Program on Multimedia through Internet: Molecular Biology, Genetics and Genetic Engineering

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Abstract

This work describes the Educational Program in Molecular Biology, Genetics and Genetic Engineering, implemented as a WEB application, developed by the Health Informatics Center of the Federal University of São Paulo. The aim of this Program is to support training of undergraduate students.

The course contents was extracted from recent bibliography. Eventually some corrections and revisions were suggested by the Professors in charge of these disciplines.

The application has 230 pages of hypertext (HTML files), 357 images, 8 animations, 31 audios, and 15 additional links with other Internet addresses connected to the Course theme. The application was validated under several WEB interfaces.

From the six designed modules, five are already available in the WEB address: http://www.epm.br/ge/CAPA.HTM, in the Portuguese version. Two new versions are presently being developed, in English and Spanish, and should be available in the WEB by the second semester of 1996.
Hypermedia Learning Environments: A Research Review of the Effects of Cognitive Style on Performance

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Hypermedia software and networks are quickly becoming popular with many educational institutions and curriculum programs. The interactive nature of hypermedia seems to be ideal for exploring and constructing knowledge. Over the past decade, research studies have examined the effects of hypermedia on learning and raised some interesting questions. The more pertinent and interesting ones for this paper are: Will learners form better conceptual models when using hypermedia or will the richness of the information overload them and deteriorate the effectiveness and efficiency of learning? What type of learner is more likely to effectively utilize a hypermedia environment? It has been generally hypothesized that persons having general ability (e.g. certain cognitive or learning styles) should perform well in hypermediated environments. More recently, a number of empirical studies have been performed to substantiate this claim (mostly with adult subjects). A review of this research, albeit mixed, seems to indicate that learners with certain cognitive styles (labeled active, exploratory, or field independent) perform better in a hypermedia learning environment that those with others. However, this general outcome seems to be manifested when cognitive style interacts with other experimental factors (e.g., attitude, advisement). It seems that more work is necessary before a more conclusive claim can be made. In particular, empirical studies with other age groups as subjects (e.g., young children, adolescents) and more research on how cognitive style interacts with other major factors (e.g., the structuring of the knowledge domain) is highly encouraged.
My Top 3: A Novel Idea for Constructing Learning Strategies in Educational Hypermedia?

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What do savvy epistemologists and college faculty share? They understand the import of connecting new material to stuff students already know. Discerning what students’ know, however, can be hairy.

Following Plato’s advice (Do not keep children to their studies by compulsion, but by play.) and recent market research (A majority of Americans spend most of their time sleeping, working, and entertaining.), I piloted My Top 3: a questionnaire of students’ top three TV shows, radio stations, reading material, things to do and/or places to go, and (your choice) activities. Playfully, I tried to identify students’ cultural syntonicities and, thus, to bridge unfamiliar concepts.

Is it foolish to advise educational hypermedia designers to administer formative PlayVentories to targeted students? Is it equally foolish to discount the utility of some vehicle for mobilizing students’ cultural syntonicities as stepping stones to new material? Is My Top 3 a novel idea for constructing the intersection of personal importance, association, and learning?
Abstract

The working hypothesis is that computerized educational multimedia and hypermedia based on learning by discovery and used as supporting material for self-teaching will favour more rapid learning. The association between practice-theory-practice will be greater and more significant for students enrolled in the Seminary for Thesis Preparation especially regarding the formulation of research problems.

A guide for evaluation of educational computing packages will be used, which includes content, educational and technical characteristics, quality and recommendations. It will be used by professors who teach the subjects included in this study and who will evaluate the Cem.

For empirical validation, a field test will be performed using four experimental groups chosen randomly. The first group will be subjected to a pre-test, the use of the Cem and post-test; the second will not be subjected to a pre-test, the Cem and then solve and post-test, the third will use the Cem and post-test and the fourth will not use the Cem but will solve the post-test.
Interactive learning tools are a cost effective way of giving differing experiences to students. The research focused on the use of two interactive tools—Simulation and Multimedia—for an effective teaching of material handling.

The simulation tool provides the students with three different types of plant layouts: Process Layout, Group Technology based Layout, Functional Layout and a set of common products. The features are: run time model, animation, material handling costs, parametric model, optional layouts. Several runs of module will enable the student to construct a P-Q graph for the example factory.

The multimedia tool deals with information on material handling equipment used in a manufacturing setup. The features are: about 30 minutes of video showing application of various types of material handling equipment, around 80 pictures of various type of material handling equipment, interlinking of video, still pictures and explanatory text. The module is Question driven to make it more interactive.
In the foreign language classroom concordancing programs can be used for the following purposes:

1. Teaching grammar in an inductive rather than in a deductive way.
2. Exploring the vocabulary of the foreign language.
3. Comparing different genres of texts for gaining a feeling for different styles.
4. Teaching literature.

The repeated use of concordancing programs in the foreign language classroom will help in the following ways:

- It will change the pupils’ learning strategies from only following the teacher's orders to taking their own responsibility for their learning process.
- It will change the teachers' role to a person who supports the students' more independent learning processes.
- It will open foreign language teaching to dealing with more authentic, more realistic, more up-to-date and therefore more relevant texts.

In my demonstration I will explain the theoretical background and will elaborate on some examples in detail.
Kutiyattam: Marriage of an Ancient Art and the New Technology

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Kutiyattam, the Sanskrit theatre of India, is the world’s oldest surviving genre of theatre, dating from at least the tenth century AD. This presentation focuses on the delicate process of wedding an ancient art to current multimedia technology. The program was designed and developed on HyperCard 2.3. In addition to numerous QuickTime movies, hundreds of color photographs, and nearly an hour of sound, it contains the first digitized devanagari text and English translation of the Hastalakshanadipika, an ancient Sanskrit manuscript which serves as principal source of the gesture language of the actors. The program contains many articles on Kutiyattam and explores its unique style of chanting dialogue, physical exercises and massage, eye exercises and conventional facial expressions, and the unique rhythmic accompaniment for all performances. In addition, it explores Kerala State, the home of Kutiyattam, the performance community, plays and performance manuals, costumes and makeup, theatre architecture, and audiences.
The predominant form of structuring computer based training systems for software handling is function-oriented. The learner is trained functions of the system, for example different menus, dialog-boxes etc. approach does not meet the needs of most software-users. They want to know how to efficiently use a software to solve their problems, for example writing a report or managing a project. Therefore not only do they need to know how to handle specific menus, they want to learn what methods to use and especially how to proceed to solve their problem using software tools. The question is for example, how do I do project management using a specific software.

The ARIS-Mentor is a learning environment designed to teach methods, procedures and the handling of a software package for Business Process Reengineering, the ARIS-Toolset. Following the paradigm of process-orientation, the ARIS-Mentor integrates knowledge of different domains along the process of learning.
Computer Interactive Case Studies in Teacher Education

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Traditional Case studies are an excellent teaching tool in teacher education because they force the students to engage in reflective thinking about a particular issue. However, they are one-dimensional; that is, there is no immediate feedback on the consequences of one's reaction towards a problem.

With the advent of powerful computers and hyperstack software applications it is now possible to develop much more sophisticated and real-life case studies which offer the possibility of built-in decision making scenarios.

During the past several semesters I have created four case studies on a variety of topics with which a secondary teacher might be confronted. The case study programs were available to the students on disk, in several computers labs on campus, or they could download copies via the Internet. Over the past two years they have been field tested in several classes and the results have been very encouraging.

For instance, 87% said the computer approach caused them to think more critically about their actions. In addition, 80% also responded that the computer case studies were also more realistic and life-like. And finally, 91% stated that the computer case studies challenged their analytical abilities the most.

Clearly, the students found the computer case studies superior as a learning tool. The few negative comments dealt almost exclusively with mechanical and technical problems associated with the computer hardware.
As teachers with limited entry-level ability begin to design knowledge environments using hypermedia applications, questions arise over their ability to develop effective learning tools [Ullmer 1994]. In this preliminary investigation, 15 experienced teachers demonstrated they could develop instructional modules purposely designed for their identified audiences. They were judged to show indications of incorporating aspects of 10 of the basic 20 Guidelines for interactive multimedia [Park & Hannafin 1993]. In terms of future usefulness, producing a hypermedia instructional module was ranked first by the students from a list of 10 instructional course activities. Although future efforts need to be directed toward developing more effective instructional approaches for instilling the 20 Guidelines into hypermedia authoring by educators, this investigation, that resulted in teacher-developers being capable of meeting some of the standards, was consistent with other studies of teachers’ work in developing multimedia [Jones & Smith 1992].

References


Challenges In Developing an Effective Distance Education Delivery System in Malaysia

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Abstract: Distance education is seen as the best alternative to the conventional mode of educational delivery in institutions of higher learning. This is especially true for a fast developing country like Malaysia where there is a great need to liberalize and democratize higher education for all. Despite its efficacy, there is still much to be developed about its mechanisms and strategies in teaching and learning. This paper examines pertinent components in developing effective delivery system for distance education in Malaysia. It discusses the experiences and practices of four local higher learning institutions, that is, the University Science of Malaysia, the National University of Malaysia, the Mara Institute of Technology and the Agriculture University of Malaysia. It examines the evidences of the effectiveness of the implementation of their distance education programs in relation to its administration and management, the preparation of instructional materials and the delivery system and other support system. The paper highlights the incorporation of technology especially computers and multimedia in distance education. Finally the paper draws conclusion on challenges for future development of distance education in Malaysia.

Introduction

In our quest to become a fully developed nation by the year 2020, Malaysia faces new task and challenges in education; that is increasing access to institutions of higher learning. Despite the steady growth in Malaysian higher educational system in the past two decades, the unmet demands for higher education in the country is increasing. Presently, there are only about seven percent of its citizen, age cohort 19-24 years old, enrolled in institutions of higher learning. This is still very far from our target of having at least 30 percent of the population enrolled in tertiary education (Mat, 1995).

The government realises that the conventional education system is simply not capable of catering the country's tertiary educational needs. As such emerging government policies is increasingly turning to distance education as a means to increase student enrolment in institutions of higher learning.

Responding to the national educational needs, and most probably to regional as well as international competitions, more Malaysian higher institutions have started offering courses through distance education. Currently, there are four local institutions of higher learning administering distance education programs. They are University Science of Malaysia (locally abbreviated as USM), Malaysian Institute of Technology (ITM), The National University of Malaysia (UKM) and University of Agriculture Malaysia (UPM).

Distance education offers a uniquely flexible learning which enable those otherwise not able to attend tertiary education, due to personal and work commitments, to continue their education. Despite this distinct advantage, research and experience have indicated that one of the legitimacy of distance education depends on its...
effectiveness of delivery. We need to look at the evidences of achieving the desired effectiveness in the implementation of distance education. The aim of this paper is then to examine those evidences based on the practices and experiences of the four Malaysian institutions of higher learning i.e. USM, ITM, UKM and UPM. Some of the major components related to an effective distance education delivery system is discussed and this include the administration and management of distance education, the preparation of instructional materials and the delivery of distance education and the support system. Implications of the utilization of technology, especially computers and multimedia in distance education is explored. Finally the paper discusses the challenges of delivering an effective distance education in Malaysia.

Administration and Management of Distance Education

In some countries, such as the United Kingdom distance education was started as far back as 150 years ago through correspondence courses. Since then it has grown steadily and in the process has introduced various sophistications in its delivery mechanisms, especially with the availability of modern high-tech and cutting edge technology in the past few decades. Basically, there are two models of administering distance education among institutions of higher learning worldwide. The first is the single mode of distance education institutions that is, those who provide distance education mode only as practiced by some institutions in the world like the Open University in the UK, Open Learning Agency in Canada, Singapore Institute of Management and Anatolian Open University in Turkey. They can either be full degree granting universities or act predominantly as a broker for the delivery of distance education programs of accredited universities.

All distance education institutions in Malaysia are of dual mode institutions. They offer similar courses in both in-campus and distance modes. One of the major challenges in this system is the increased burden in the academic workload. Those staff that are already burdened with in-campus teaching will have to take extra load with the distance education teaching programs. Too often we find difficulties of getting strong and sustained commitment from the faculty members.

Malaysian higher institutions have found some ways to overcome the problem. USM for example, have made distance education as part of their university program. Thus their staff involved in distance education are full time staff. Once they are involved in distance education then they are not required to teach in-campus program. They are also allowed to teach a combination of in-campus and distance education courses.

Other institutions resort to providing extra incentives for those involved in distance education teaching. UPM identifies staff those are interested in teaching distance education and provide them with monetary incentives for developing distance education learning packages and also teaching distance education courses. This means that teaching distance education courses are considered as added responsibilities for the academic staff.

In managing effective distance education courses, Malaysian institutions of higher learning found it necessary to collaborate with others. UKM conducted their medical program by having intersectoral collaboration with the Ministry of Health (MOH). Their intersectoral roles are clearly defined by consensus reached in discussion between the two parties. The MOH is responsible for physical facilities (hospital and health centers), upgrading of hospital equipment and audiovisual aids, providing specialists who will act as supervisors/honorary teachers and doctors who will become students in the program. On the other hand UKM coordinates the program, provides distance education technology, provides equipment to help in the delivery of distance education, provides training of supervisor, conducts the teaching, monitors and assesses students, evaluates the program and pays the honorarium for the supervisors. There are also joint responsibilities which include developing policies for implementation, criteria for appointments and accreditation of training centers. Financing is also shared. The university also works closely with Telekom Malaysia to facilitate teleconferencing sessions and the POSLAJU Malaysia (Express Post Malaysia) to help in dissemination of materials. The distance education program is conducted by the Medical Faculty.

Other institutions operate their distance education through specially established centers. USM conducts its distance education programs through the Center for Distance Education. The Center collaborates with the Ministry of Education which provides selected schools and polytechnics as learning centers. Currently it has established 11 Regional Centers (for science and art programs) and five Regional Centers (for engineering programs) set up in various states in Malaysia. The largest Regional Center is at Kuala Lumpur which has an enrolment of 527 students out of its enrolment of 3,289 students for the academic session of 1994/95 (Salleh, 1995). The Center for Distance Education, USM also works closely with Telekom Malaysia in facilitating the
audiovideoconferencing and the Postal Department in the dissemination of learning materials. Presently, the Center offers a total number of 169 distance education courses, comprising 79 courses in the sciences and science foundation programs, 30 in the social sciences, 29 in the humanities, four in English, 16 courses in civil engineering, five courses in electrical and electronic engineering and two in chemical engineering and six other courses (Salleh, 1995).

On the other hand, UPM manages its distance education programs through the Institute for Distance Education and Learning (IDEAL). The Institute works closely with faculties in the university who provide the academic programs, the content specialists for writing the learning packages and the teaching staff. Basically the faculties are responsible for controlling the quality of the programs that are provided for distance education. IDEAL acts as the manager for the program. The university also works closely with the private sector in implementing its distance education programs. For example, it collaborates with CELCOM Malaysia, a cellular communication company, in delivering the Bachelor program in computer science. CELCOM promotes and markets the program, manages the students, provides the learning centers, the infrastructures for delivery of distance education programs and the initial financing. The university, on the other hand, is mainly responsible for academic matters. Presently, UPM offers two academic programs in the distance mode i.e. Bachelor in Computer Science and Masters in Human Resource Development. In the near future it will conduct more distant education courses in the fields of economics, business and education. The distance education is run as a self-financing project.

The distance education in ITM is managed by the Center for Extension Education. Its distance education program is A...to provide the working bumiputra communities throughout Malaysia with academic opportunities to improve and enhance their academic qualifications, knowledge and working efficiencies@ (Junid, 1995). ITM offers three courses for distant learning which include Diploma in Public Administration, Diploma in Banking Studies and Diploma in Business Administration. It utilizes ITM=s nine branch campuses as its learning centers. Thus distance education students are enrolled at those centers and enjoyed all the facilities as received by full-time students.

USM and ITM have full-time staff for managing their distance education programs while UKM and UPM utilize part-time faculty members.

Instructional Materials and Delivery of Distance Education

The practices of the four institutions point to the significance of utilizing self-instructed learning packages (SLP) as an effective delivery of distance education. Obviously the major advantage of the SLP is that it can be studied anywhere suitable -- at home, in the library and in the workplace. The learning packages are meant to be used by the learners individually. Thus it has several implications toward the design and style of presentation of the materials. Some of the criteria that are important:

1. Objectives or outcomes of the learning are clear and relevant
2. Introduction gives the learners a clear idea of the expectations of the course
3. The contents of the modules are sequenced in a clear and logical manner
4. The learners should be involved actively in a variety of ways in the learning process
5. The learners should be able to gauge their own progress through self-assessment and other activities
6. Students assessment should measures all the objectives and the major content areas in the modules
7. There should be a number of ways how students are assessed - assignments, examinations and projects.
8. Develop some form of positive and helpful feedback during the learning process
9. Provide an appropriate pace for students to learn -- the contents are divided into units that can be learnt in a single sitting; difficult concepts are supported by adequate illustrations
10. Provide illustrations, examples, graphics, samples, pictures to help students to understand the subject matter
11. The layout of the module should contribute to understanding of the contents by having clear headings, good typeface, helpful keys and diagrams, good spacing and color scheme if necessary
12. Provide adequate spaces for students to provide responses
13. Support text with videos, cassettes, multimedia but they should be integrated with the learning of the modules
14. Provide adequate guidance or training to the tutors/supervisors who are involved in facilitating the learning process.
Various mechanisms are used to deliver distance education. USM distributes all the learning materials during the orientation session in the month of May at the campus. The orientation is compulsory for all distance education students and failure to attend will result in the withdrawal of their offers. Similarly UPM distributes printed learning materials during the orientation held in the campus at the beginning of each semester. Materials on the internet are made available to students during the semester, distributed according to the lesson plan. The students will study the SLP individually and will be supported by teleconference, on-campus meetings, tutorials, weekend courses, mentoring, counseling sessions, telephone calls, faxes and correspondence, electronic discussion and other media such as tapes, videos and multimedia. At the end of the course the students are assessed by various means such as examinations, assignments and projects. For example, UKM monitors students’ performance throughout the 4 years through supervisor=s report (40 percent), family case studies (20 percent), logbook and analysis of practice dairy (20 percent) and end of posting test (20 percent). ITM assesses students on projects, tests and quizzes (30-40 percent) and final examination (60-70 percent).

Support Services

Based on the experiences of the four institutions several strategies can be done to facilitate learning in distance education by providing some of the following support services:

1. Provide the students with orientation program, usually at the beginning of the semester. For instance, UKM provides a two-week intensive course at the beginning of each academic year emphasizing the understanding of family education curriculum and its implementation using distance learning strategies and assessment; the application of techniques of communication, problem-solving, decision making and time management; skills of using teleconferencing system and SLP materials; importance of the role of Family Medicine Specialists in improving health care services and students’ responsibilities.

2. Provide the students with a time table and work study schedule with the teacher and tutor. USM provides distance education students with Acourse planner@ which contains a comprehensive guide to all assignments, practicals, tutorials and tele tutorials, students assessment, intensive course and examinations.

3. Provide the students with a tutor so that they have group discussion, preferably at the learning centers. USM provides resident and part-time tutors and students are required to attend 4 tutorial hours for 1 unit course. ITM=s seminar or tutorial is held 4 times a semester for each subject while for UPM tutorial is held 5 times a semester for a 3-credit course. UKM appoints senior doctors as tutors and mentoring is part of the learning process.

4. Arrange the students to discuss problems or pertinent issues with fellow students in scheduled or unscheduled sessions.

5. Establish strategic learning centers throughout the country to support students learning activities such as discussion, meetings, resource centers and places for conducting the examinations.

6. Have a few face-to-face meetings with the lecturers during a semester. UPM insisted that the lecturers have at least three face-to-face meetings per semester. The nature of meeting varies from institution to institution. For example USM instituted a 3 compulsory weeks (4 weeks for engineering) residential requirements for every students, especially for practicals using sophisticated equipments/instruments not available at the learning centers. The intensive courses are held during the long vacation. ITM provides seminar to students so that they experience the environment of a full-time program while UPM provides in-campus meetings with the teaching staff.

7. Develop communication access for the learners to reach teachers -- telephone, facsimile, electronic mail and correspondence. Most institutions provide students with scheduled and non-scheduled communication. USM appoints a panel headed by a Counseling Coordinator to provide non-academic counseling. Each panel member is assigned about 10-15 students. The academic counseling is provided by the tutors at the learning centers.

8. Develop teleconferencing sessions which provide an interactive planned teaching-learning session. ITM and USM provides audiovideoconferencing while UKM utilizes audioconferencing.

9. Provide the students with mentors. UKM provides supervisors to students who are usually senior staff at the workplace (hospitals)

10. Develop media to support the self-learning packages to students. USM insisted that SLP should consist of 30 percent multimedia and 70 percent printed materials. ITM provides audio or video recorded tapes to facilitate students for their understanding, comprehension and retention of the subject matter.
Technology and Distance Education

Educational institutions have been employing various technologies into their teaching programs. Indeed this is a key feature of the institutions which are gaining reputations for being innovative and at the leading edge...The new and emerging technologies have the potential to provide a means for improving the quality of teaching and learning across the university... (Holgate, 1995).

Experience and practice of the four institutions indicated that they have incorporated many of the educational technologies indicated by Holgate (1995). The technologies utilized by those institutions in their distance education programs include:

1. Telephone/facsimile -- USM, UPM, UKM, ITM.
2. Computer-mediated Communication -- E-mail (all institutions), electronic discussion (UPM), bulletin boards and computer conferencing (none)
3. Audio -- audioconferencing (UKM), radio (USM), PABX (UKM)
4. Audiographic -- USM
5. Computer-based learning -- interactive media (limited utilization by USM, ITM), hypermedia (none), internet (UPM)
6. Videoconferencing -- USM
7. Television -- broadcast (USM), pay TV (none), interactive (none)
8. Computer-managed learning -- virtual learning (in the process to be introduced in UPM).

The utilization of technologies, especially computers will be more common and widespread as there will be a wider range of technology accessible and cheaper and better technology available.

In the future, computers will be the main enabling technology to support an effective distance education in higher institutions. In computer-mediated communication (CMC), students and teachers communicate, discuss and collaborate on projects@ (Abas, 1995). As such more Malaysian higher institutions are incorporating computers as a major tool to support distance learning and teaching. Perhaps UPM has taken a great leap forward by developing materials on the internet for students following courses leading to the degree of computer science. This new mode of learning has introduced new ways of communication between students and teachers -- the electronic mail and electronic discussion. Initially, there are several challenges in setting distance learning and teaching through the internet viz-a-viz: (1) Infrastructures -- frequent breakdowns and also difficulty of getting access, (2) conceptualizing on-line education -- the teachers and students are still in the process of familiarizing themselves to the process, (3) designing an effective educational packages, especially making the materials more interactive and attractive, (4) managing learning on-line and (5) copyright of materials.

Conclusion and Future Challenges

Malaysian institutions of higher learning have to develop an efficient administrative and management for distance education. Thus far, our experiences have indicated that being a dual mode institution of distance education providers the commitments of faculty members can be a major problem. The choice is between choosing full-time faculty members or part-time faculty members. Having full-time faculty members the universities have to bear a very high cost of operating and sometimes the universities have to subsidize the program. Employing part-time faculty members means giving adequate incentives, both monetarily and other forms of recognition to sustain interests and commitments. By this mechanism distance education have to be run as a self-sustaining program.

If distance education is to be effective, it has also to provide quality teaching and learning. Since distance education is basically individualized learning, the learning materials must be prepared adequately to ensure that the students can follow the course systematically. The learning packages should include print, video, tapes, computer-based learning and multimedia. There is also a need to support learning by face-to-face meetings, orientations, tutorials, counseling sessions, orientation, on-campus meetings, practicals, regular communications by telephone, faxes, e-mail and correspondence and systematic assessment. An adequate training for academic staff must be given so that they can attuned themselves to the peculiar needs of distance education. Specialists also have to be developed and trained, especially for those responsible for designing those packages and for those involved in the development of computer-based learning and multimedia. Ultimately, distance education
should adopt the concept of virtual learning. For distance education to be an effective means of mass education at the tertiary level there should be an initial cost for investment in training of staff, development of SLP packages, setting up of remote learning centers and other infrastructures and purchase of appropriate technologies. There should also be collaborative efforts between local higher institutions of learning and abroad and also the private sectors in order that distance education will be a viable option as an instrument toward achieving the goal of education for all in the country.

References


Principles of reinforcement have long been of interest to educators. Multitudes of studies indicate that both the reinforcer and the method and timing of its application are important. The question remains, however, of what should happen when an incorrect answer is offered by the learner, and when? How can we use electronic tutors to advantage in this context? Students using an electronic statistics tutor for a section on descriptive statistics were either required to correct errors on tests, given the option of correcting those errors or simply given the correct answer. Mandatory correction of incorrect responses, as part of the summary information at the end of a test, provided the most effective reinforcement in this computer assisted statistics tutorial. These results were maintained and enhanced over a period of 11 weeks. These findings are of direct relevance to the designers of computer assisted learning protocols.
Creating Engaging Courseware Using System Dynamics

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System dynamics based learning environments consist of: introductory tutorial; overview of a dynamic model of a complex phenomenon; learner access to model variables; opportunities for learner manipulation; learner interpretation of simulations; and opportunities for learner construction of alternative models. Feedback and discussion are integrated throughout. Cognitive engagement is achieved by establishing a context for learning, by facilitating learner control, and by introducing unexpected outcomes in need of further explanation and exploration. Such environments begin with an enabling phase supported by the introductory tutorial. Next comes a processing phase in which learners become involved with the underlying model. The learning experience concludes with a resolving phase with group discussions of interactions with the model. This session features a demonstration of creating such environments.
Experimental and Virtual Laboratory: a Strategy for Modelling in Physics Education.

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This paper is concerned with the computer as a pedagogical tool for a physics teaching strategy focusing on model development and deployment. The objective is the learner construction of different representation of the reality at various complexity levels by evidencing the features that interest the modeller, i.e. the variables characterising the real process. The computer, using probes and sensors produces the measures of these variables and gives the relationships among them using graphical displays. The learner, then, starts its modelling process using the Virtual Laboratory, i.e. a microworld functioning on the base of physics laws and tries to reproducing the phenomenon through a multilevel controllable empirical framework. We will describe a pilot course for teacher training using this strategy and will discuss some preliminary results.
New Media for an Old Method: Using Multimedia and Hypermedia in Case Studies

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Case studies have long been used in diverse disciplines to compel students to broaden their understanding of general principles through the tightly-focused lens of specific situations and concrete circumstances. New media introduces the possibility of enriching this age-old approach in myriad ways. The Case Program at Harvard University’s John F. Kennedy School of Government is experimenting with multimedia and hypermedia to foster the case method’s primary goal: converting education from an abstract intellectual exercise into one in which students can bring to bear their intuitive as well as intellectual understanding of a situation to help imagine solutions to various problems. The demonstration contrasts two approaches to designing new media case studies: the first using digital video on CD-ROM, “The Problem at 231st Street” (Case catalog number: C18-95-1275.9); and the second created for the World Wide Web, “Campaign ‘96: Third Party Time?” (http://ksgwww.harvard.edu/third-party).
The Beats: Tools for Supporting Response-Based Literature Teaching and Learning

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The Multimedia and Literature Teaching and Learning Project [Swan & Meskill, 1995] has found that the multimedia literature applications currently commercially available, although technologically quite good and perhaps supportive of text-based pedagogies, are not inherently supportive of response-based teaching and learning. In particular, commercial applications fail to provide adequate support for discourse among students concerning literary works. The project has accordingly concentrated on creating tools that do just that. This presentation will demonstrate these tools as they have been instantiated and studied in an application on The Beats designed for high school and community college students. The Beats is an open-ended ToolBook program which is centered on the texts of the works of Jack Kerouac, Allen Ginsberg, William Burroughs, and Lawrence Ferlinghetti, and includes recordings of these authors reading some of their works, jazz music, and period radio interviews from the Rhino audio CD set entitled the Beat Generation. Presenters will include students and teachers as well as the designers and developers of the application.

References

How Students Have Used a Discussion List in a Course

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An electronic discussion list has been used in many ways by students who enrolled each semester in a science methods course, including to: answer instructor's questions, provide interesting information, follow up on classroom activities, seek and receive ideas, share science activities, submit assignments, share internship experiences, provide feedback regarding course assignments, and to offer feedback about the discussion list itself.

Messages posted on the list during Spring 1995 will be excerpted and reproduced to illustrate the different ways students have used the list during the first two years of its operation. Comments made by students regarding their experiences with the list will also be shared during this poster session.
Interactive Design of a Hypermedia Tutorial via Rapid Prototyping

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The traditional Instructional Systems Development approach is not capable of handling highly interactive instructional technology. To improve the efficiency and effectiveness of the development process, Rapid Prototyping was used. Rapid Prototyping is the process of developing and evaluating prototypes in a short period of time. The primary use of the prototype is to realize the conceptual structure of the product without incurring the expense of the full product development cycle. The Rapid Prototyping method was divided into five phases: Requirements, Design, Implementation, Integration, and Maintenance. The findings of this case study were: The rapid prototyping methodology 1) improved the communication within the design team, 2) increased team members' productivity, and 3) reduced the development time and cost. Since each phase of the process was fully evaluated and tested before advancing to the next phase, the possibilities of making errors and changes were reduced, resulting in dramatically reduced time and production cost.
Teaching and Learning Through Multimedia: Theoretical and Applied Issues

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The paper presents a case study about teaching and learning through interactive multimedia, applying the concept of multiple intelligences.

The main goal was to produce a multimedia as a resource to acquire knowledge on architectural and geographical spaces, considering some learning and perceptual difficulties observed in the majority of students. These difficulties are related to space perception and construction, representation and visualization of architectural/geographic data, understanding basic concepts such as scale, point of view, projections, location and orientation.

These concepts were presented in a way to give the opportunity for the users to explore and enhance their several intelligences and habilites, including the verbal/linguistic, logical/mathematical, visual/spatial and bodily/kinesthetic.

Finally, it was considered the user evaluation in terms of communication efficacy, learning potential and degree of motivation. These actions should aid educators to use hypermedia tools, in order to facilitate as well as to enrich the teaching process by offering new learning environments.
Standards-based Educational Reform and Interactive Technologies: A Multimedia Application for Undergraduate Human Services Education

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Standards-based accountability and cost pressures in post-secondary institutions will shape the infusion of interactive multimedia leaning environments in various curriculums. The Community Support Skills Standards Project has established national voluntary skill standards for the human services industry and conducted pilot implementation studies of these standards in several post-secondary institutions. The use of interactive technologies in several pilot sites will be described. Community Visions, a multimedia training application which builds knowledge and skills for vocational services to persons with disabilities, will be demonstrated. This application allows self-paced exploration of basic concepts, and engages students in simulations of community-based vocational assessments, job development, and support. Results from the simulations can be integrated in collaborative group classroom activities. The ways that this multimedia application enables undergraduate human service, special education, psychology and social work programs to adapt their instructional and assessment strategies to outcomes-based accountability will be discussed.
A Telescriber Is . . .

an approximately 2” x 4” x 6” piece of equipment with accompanying cabling and software which allows the capture of closed-captioned text from television programming directly into a computer. The captured text can be used as is, saved in a teachtext file, marked with key words, sent to a connected printer, or imported to a word processing program for editing.

With a Telescriber, an Instructor Can . . .

create exercises which focus students’ learning on terminology (vocabulary lists), grammar, technical vocabulary, or content comprehension.

You Will Need . . .

an IBM compatible PC or Mac; a floppy drive; an RS-232 serial port; a hard disk installation of only 36kb, a standard 75 ohm video source, an NTSC video input, a wordprocessor accepting ASCII text, and approximately $700.

Telescriber Equipment Source

Pacific Lotus Technology, Inc.
411 108th Avenue N.E., Suite 235
Bellevue, Washington  98004
1-800-243-2710
In this qualitative study of the navigational choices made by university freshmen composition students using a computer multimedia vocabulary program, twenty-two students were asked to learn 12 vocabulary words from a program that included digitized text, photographs and movies. Findings indicate that: (1) Students navigated through the program systematically and were aware of the strategies they used to select certain nodes. (2) Students preferred to activate nodes linked to visual representations of information because they perceived that medium as more interesting and more like the way their memory operated. (3) Students perceived the digital films to be a more efficient instructional medium than print; reading required more mental effort than viewing. (4) Students who activated primarily visual information did so because the medium was commensurate with their perceived learning styles.
Learning Computer Programming as an Apprentice: Improving Undergraduate Course Teaching

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We have improved an undergraduate course of educational computer programming and its philosophy at the Department of Education in Tamagawa University. Our purpose is to give a perspective of educational computer programming to learners. For this purpose we have developed teaching programs for HyperTalk and HTML programming lessons. Any one is practical. For example, some of HyperTalk lessons are used for the Japanese Language teaching for foreigners. The HTML teaching program with CGI lessons asks students to develop WWW pages for our cooperative works. They learn them individually for the educational purpose as apprentices. In 1995 - 6, 23 Senior and junior students were there. They were also engaged in developing the software for the Kindergarten etc. and teaching the elementary school pupils in the same campus. Our important job is to find tasks for students.

In our session, we will mainly show the lesson programs and their products.
Hypermedia Interface: The Effects of the Number of Links and Granularity of Nodes on Learners' Information Searching and Learning Performance

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The study, using cognitive theories as general theoretical framework, investigated the effects of the number of links and granularity of nodes on learners' information searching and learning performance in hypermedia systems. These effects were compared in four different experimental systems--larger nodes/dense links, larger nodes/sparse links, smaller nodes/dense links, and smaller nodes/sparse links. The effects on learners' information searching and learning performance were assessed in four different tasks--general and specific information searching, multiple choice questions, and brief summary writing.

Results showed that four systems are significantly different from each other (F=5.89, P=0.0006). Students performed best in the hypermedia system (smaller nodes/sparse links) and worst the hypermedia system (larger nodes/dense links). The study also showed that cognitive overhead and disorientation are both closely related to the number of links and granularity of nodes, which in turn, influenced students' performance in information searching and learning.
A knowledge of problem-solving is a necessity for students doing a first course in Computer Science. Usually the focus is on designing of algorithms and the teaching of programming concepts and data structures.

It is our experience that students have greater difficulty with the solving of problems than they do with learning syntax of programming languages.

Dealing with a diversity of students from very different backgrounds motivated us to look into alternative ways to teach students problem-solving.

A possible solution to this problem was to design a multimedia program to assist students in learning the skills of problem-solving. The program focus is on the teaching of problem-solving skills like read, recognize, analyse and practical problem-solving experiences necessary to solve a problem by means of a functional programming language.
Physical planning is a complex dynamic process which involves taking decisions regarding different spatial components and socio-economic agents. In the first year of their studies at the Faculty of Architecture students are faced with, for them, quite abstract design task to develop the plan for the new urban areas within Randstad, which is the highly urbanised area in the west of The Netherlands, fringed with the cities of Amsterdam, Rotterdam, The Hague and Utrecht.

Within this context, the use of GIS and multimedia is supposed to allow students a powerful learning tool, which will enable them to formulate the designs and to test the results of the alternative spatial strategies that they produce.

The design of the application is simple and user friendly. It contains the basic information about Randstad, which are presented by text, digital maps, photographs, sound and video.
The Internet, ....and the Changes it has Wrought!

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Education at a Distance and Quipunet:

Seeing the great need for education in South America, and taking advantage of the potential offered by the new medium of communication, a voluntary group of Peruvians formed and organized Quipunet entirely on the Internet. A cybernetic human link, offering their knowledge and help to Educate at a Distance.

Quipunet's main objectives are:

- To channel educational resources, material and knowledge to poor people in Latin America, especially Peru.
- To promote the development of educational programs at all levels, and make it possible for schools in remote areas to access them.
- Within this framework, Quipunet wants to promote and collaborate in an exchange of information and experiences with the people of the Hispanic world.
Obstacles to the Implementation of Computer-Assisted Reporting Courses

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Abstract: Computer-assisted reporting, or CAR, includes the use of computers by reporters for gathering and processing information in every phase of news story development. A panel of educators and journalists with experience in CAR addressed the following questions in this study: What benefits will journalism schools realize from the introduction of computer-assisted reporting courses? What problems will the schools encounter in the process? How might those problems best be addressed?

The Delphi method was used to seek consensus among a panel of CAR experts regarding the benefits, problems, and problem solutions associated with introduction of computer-assisted reporting courses in journalism schools. The Delphi respondents foresee a plethora of benefits for students in CAR programs. According to the panel, students will acquire knowledge vital to their future jobs and beneficial in other university courses; develop statistical, analytical, and computer-reporting proficiencies; enjoy an improved learning environment; and have a broader perspective of available news sources. The most likely problems university journalism programs will encounter in the process of introducing CAR courses are cost of equipment, lack of qualified faculty, maintenance of equipment, class sizes limited because of equipment costs, and curriculum revision necessary for CAR courses.

Introduction

An investigative reporter for a major midwest newspaper recently utilized a computer to compare one state's department of corrections database of over one-half million convicted criminals with their education department database of 100,000 teachers and bus drivers. He discovered there were nearly 200 convicted felons in the state's classrooms and another 200 driving buses. The charges included murder and child molestation. The education department admitted negligence in checking applicants' records, and the state quickly passed a statute requiring criminal checks on all teachers and drivers [Borsi 1993].

There is little question that journalists with CAR skills, such as the reporter above, are in demand. Noting that reporters using computers for data retrieval and analysis have won Pulitzer Prizes the last six years in a row, U.S. News and World Report recently listed CAR specialist for print media as one of 20 "hot job tracks" for the future:

Journalists can improve the odds of breaking in and moving up by mastering computer-assisted reporting techniques.... Dozens of papers have trained or hired specialists in computer-assisted reporting in the last few years, and more will as the costs of equipment drop and databases become available through online services [U.S. News 1994].

Computer-assisted reporting, or CAR, includes the use of computers by reporters for gathering and processing information in every phase of news story development: obtaining story ideas from computer databases, online services, networks and bulletin boards; collecting and analyzing information from government and private databases; verifying information received from human sources via online services and databases; and creating databases at the newspaper to statistically analyze information for stories and graphics [Paul 1994].

Despite advances in computer-assisted reporting being made by America's newsgatherers, most university journalism programs have yet to introduce their first CAR course. However, fundamental CAR techniques are quickly becoming part of the standard repertoire in many of the nation's newspapers. Beginning with a literature review, this paper outlines a research study addressing this disparity.

Referring to the rapid development of computer-assisted reporting in newsrooms, Jim Brown, director of the National Institute for Advanced Reporting, said, "Those in the job market now who don't know how to use a spreadsheet or a database are really at a competitive disadvantage ..." [Feola 1995]. Two-thirds of the 208
newspapers responding to a spring 1994 survey of dailies "use computers in some manner for some type of reporting" [Garrison 1995].

The use of computers by journalists is not new. Ward, Hansen, and McLeod identify the introduction of video display terminals (VDTs) and electronic pagination software as major technological changes in the newspaper industry beginning over two decades ago. The adoption of VDT technology changed writing, editing and production processes, while the electronic pagination systems transferred much of the back-shop production work to the journalists' desks [Ward, Hansen and McLeod 1988].

In addition to editing and pagination functions, newspapers are now regularly utilizing their computers to access online databases, search computerized public records, and scrutinize government documents. In 1983, John Ullmann reported that 20 of the 54 newspapers with circulations of 100,000-plus which he surveyed subscribed to one or more database service [Ullmann 1983].

John Ullmann reported that 20 of the 54 newspapers with circulations of 100,000-plus which he surveyed to access online databases, search computerized public records, and scrutinize government documents. In 1983, John Ullmann reported that 20 of the 54 newspapers with circulations of 100,000-plus which he surveyed subscribed to at least one database service [Ullmann 1983].

Tim Miller, writer and consultant, studied the use of databases by journalists during his year as a research fellow at the Gannett Center for Media Studies. He found that the number of newspapers conducting online database searches quadrupled from 1982 to 1986 [Miller 1988]. In a study of 96 randomly selected general circulation daily newspapers with circulations of more than 25,000, Frederic F. Endres found that 21 of the publications utilized commercial computer service networks, such as Nexis and Dow Jones, to access databases and BBSs by 1985 [Endres 1985].

Endres, professor of journalism at Kent State University, discovered that most of the papers had been using database services for a year or less. Regarding the future of database use, 18 of 21 said they would either continue with the current subscription or add more. Respondents said the database services were used to gather story information in several areas: facts on individuals and corporations, details of political events, sports statistics, weather data, business information, and background material on persons, companies, or events [Endres 1985].

In 1987, Hansen, Ward, and McLeod found that 38 percent of the newsroom staff members they surveyed at one metropolitan daily with a circulation of 385,000 used electronic database sources. The sample population consisted of the newspaper's 195 reporters, editors, columnists and editorial writers. One hundred thirty six, 69.5 percent, responded [Hansen, Ward and McLeod 1987].

In 1989, Jacobson and Ullmann found that 71 percent of surveyed journalists said database searches were an "important" or "very important" component of their news reporting. Questionnaires were distributed to librarians at the 235 U.S. newspapers with circulations of 50,000 or more. The librarians were asked to pass along questionnaires to reporters or editors who used databases. Eighty responded. Seventy six percent said their searches were "almost always" useful. The perceived benefits listed by the respondents included improved detail, depth, and perspective for stories, as well as access to a wider geographic range of coverage and improved "memory" of facts. The study indicated that potential problems related to database use were not a matter of great concern. The journalists responding generally were not worried about databases leading to homogenization of coverage, adversely effecting reporting angles, or contributing to a loss of local perspectives in reporting. Nor were they very concerned that database use would discourage original work or bury reporters in data [Jacobson and Ullmann 1989].

In 1991, Ward and Hansen found that 90 percent of the 105 newspapers with circulations of 100,000-plus they surveyed subscribed to at least one database service, with a median number of four taken. In 60 percent of the newsrooms equipped with PCs and modems, reporters searched public records electronically.

The results of this study show that electronic technologies have been adopted in a large majority of the nation's biggest dailies. These technologies are used for information search, selection and analysis.... the use of the personal computer for "computer-assisted reporting" allows creation and analysis of information never previously available for news reports [Ward and Hansen 1991].

In a July 1992 survey of daily newspaper managing editors, Brian S. Brooks and Tai-en Yang, University of Missouri, found that 90 percent of the large newspapers (100,000-plus) and 55 percent of the medium-size papers (50,000 to 100,000) had conducted investigative reporting using a computer. One hundred percent of the large and 52 percent of the medium papers had used newsroom computers to "access external databases." Forty-one percent of large newspapers had used computers to read nine-track tapes. The Nexis/Lexus database had been accessed "regularly" by 78 percent of the large papers, followed by DataTimes, 68, Vu/Text, 59, Dow Jones News, 41, and CompuServe, 39 [Brooks and Yang 1993].

Three-fifths of the newspapers responding to Garrison's 1994 survey of dailies used online services of some kind. Fifty-two percent used spreadsheet software for CAR, 48 percent relational database software, and 36 percent CD-ROM readers. Forty-seven percent had created, or planned to create, a "CAR desk" or CAR project team [Garrison 1995].

These studies point to the fact that computer-assisted reporting is quickly becoming the norm for U.S. newspapers. Journalism schools have been slower to embrace these advances in newsgathering technology.
Research Questions

If universities continue the pattern they established following the introduction of VDTs and pagination systems, then CAR courses eventually will be introduced in journalism schools. Discussions concerning the future of CAR courses, therefore, should focus on "When?" and "How?" rather than "If?" This study has taken that approach.

A panel of educators and journalists with experience in CAR addressed the following questions in this study: What benefits will journalism schools realize from the introduction of computer-assisted reporting courses? What problems will the schools encounter in the process? How might those problems best be addressed?

Methodology

The Delphi method was used to seek consensus among a panel of CAR experts regarding the benefits, problems, and problem solutions associated with introduction of computer-assisted reporting courses in journalism schools. The Delphi is a research methodology designed to solicit expert opinions regarding the predicted future of a particular domain. This research technique was developed and refined during the 1950s and 1960s by the Rand Corporation to help the United States military develop long-range strategies. Since that time Delphi has been used widely in business, science and government [Allen 1978].

This Delphi study utilized a non-random sample of expert subjects. The panelists were selected based on their depth and span of experience with CAR as professional journalists or as university journalism instructors. Nominations were collected from personal interviews, articles in scholarly and trade publications, professional and academic credentials, and participation in CAR seminars and conferences. Some respondents have primarily professional experience with CAR, some primarily academic, and some a blend of the two.

Panelists included professional journalists working for numerous newspapers, a wire service, a newspaper conglomerate, a national news magazine, and a broadcast network news program. Some are Pulitzer-Prize winners or finalists. Several of the respondents hold newly created CAR positions with titles such as "database reporter," "systems analyst," "computer specialist," and "new media manager."

The panel of experts also included faculty members in higher education journalism programs at institutions ranging in size from large state universities to small colleges. Other participants included the directors of two independent CAR institutes, and library directors for a large journalism school and a national media institute.

Three rounds of questionnaires distributed in the fall of 1994 served as the research instruments for the Delphi. The first and third rounds consisted of open-ended questions designed to foster a free flow of opinions from the panelists. The second round asked respondents to rate and rank a series of statements based on Round I responses. Round I asked panelists to list up to five benefits and up to five problems associated with the introduction of computer-assisted reporting courses in university journalism programs. In Round II, experts rated the likelihood of problem statements generated in the first round on a five-point semantic differential scale ranging from "unlikely" to "likely." They also ranked the top five problem statements according to magnitude. Round III asked panelists to suggest possible solutions to the top five rated and ranked problem statements from Round II.

The Results

From a master list of 53 potential respondents, 33 journalists and journalism educators completed a reply form agreeing to participate in the Delphi study of computer-assisted reporting. Each of the 33 was sent a Round I questionnaire. Thirty returned completed questionnaires, yielding a return rate of 91 percent.

In Round I respondents listed 123 potential benefits. Similar answers were consolidated into 35 benefit statements, which fell into four broad categories: student-related, graduate-related, faculty-related, and journalism program-related. The Delphi respondents forsee a plethora of benefits for students in CAR programs. According to the panel, students will acquire knowledge vital to their future jobs and beneficial in other university courses; develop statistical, analytical, and computer-reporting proficiencies; enjoy an improved learning environment; and have a broader perspective of available news sources.

Additional predicted student-related benefits include an increased emphasis on journalistic inquiry and on facts rather than personalities; increased access to diverse viewpoints; development of connections with news professionals; heightened awareness of First Amendment and privacy issues; and realization of the importance of access to public records. According to the panel, graduates of CAR-enhanced journalism programs will also reap a harvest of benefits, including an easier time securing journalism jobs; an easier transition to other computer-
related jobs; an understanding of computer capabilities beyond word processing; and a clearer perspective of the contemporary world of computer communication.

The respondents also listed graduate-related benefits that will profit others. These include an ability to use CAR for investigative reporting to inform the public; an ability to use CAR methods to generate story ideas for print and broadcast news organizations; and an opportunity to introduce CAR to news operations that have not used it. Panelists also foresee university journalism professors as re-energized beneficiaries of CAR-enhanced programs. Faculty-related benefits include the motivation to stay current with developments in the profession; the development of more common ground between profession-oriented and research-oriented faculty members; the ability to utilize CAR databases for academic research; and the development of new connections with colleagues in other departments/programs.

Looking at the bigger picture, the respondents noted several benefits journalism programs will enjoy. These include an overall increased attractiveness to better professors and students; increased attractiveness to computer-oriented students, older non-traditional students, and mid-career professionals seeking CAR training; development of new connections with news professionals; and procurement of funding from organizations supporting CAR. Journalism school benefits also will include the opportunity for programs to become more contemporary; an increased chance of "survival" in the university; the opportunity to use CAR as a marketing/PR tool; and a better reputation among faculty in other disciplines.

Also in Round I, the panelists listed 108 potential problems. Similar answers were consolidated, and a master list of 26 problem statements was developed for use in Round II. These were grouped into five broad categories. Some problems were included in more than one group:

1) Equipment-related problems included "cost of equipment," "maintenance of equipment," "class sizes limited because of equipment costs," "offering online services to large numbers simultaneously," "lack of standard computer hardware," "lack of standard computer software," "computer hardware becoming obsolete quickly," "computer software becoming obsolete quickly," "CAR techniques becoming obsolete quickly," and "the quality of retrieved data not being assessed."

2) Institution-related problems included "resistance of university administrators," "curriculum revision necessary for CAR courses," "resistance of faculty," "lack of qualified faculty," "faculty who misunderstand economic importance of CAR," and "for purposes of promotion and tenure, faculty will devote time to research rather than learning new CAR skills for teaching."

3) Curriculum-related problems included "CAR taught as a replacement for, not complement to, traditional reporting," "CAR skills segregated in separate courses rather than taught across the journalism curriculum," "curriculum revision necessary," "scarcity of CAR teaching materials," "developing substantive student assignments," "developing new courses in statistical analysis," "the limited number of student internships," and "the quality of retrieved data not being assessed."

4) Student-related problems included "students who are apathetic about CAR," "students intimidated by computers," "meeting expectations of incoming students who have been exposed to new technology in high school and home," and "the limited number of student internships." The first three deal with student attitudes, the fourth with opportunities for students.

5) Cost-related problems included "cost of equipment," "class sizes limited because of equipment costs," and "cost of online time."

For Round II the 29 panelists were asked to rate each of the 26 problem statements, generated from Round I, by means of a semantic differential scale. The respondents checked one of five blanks between the bipolar adjectives "unlikely" and "likely" for each statement. All 29 participants rated the problems statements. The blank closest to "likely" was scored a five, the next closest four, the center blank three, the next closest two, and the blank closest to "unlikely" one.

Table I lists the problem statements in descending order from "likely" (5.0) to "unlikely" (1.0) based on their overall rating by respondents in Round II. When the means of two problem statement ratings are the same, the statement with the lower standard deviation is listed first.

In Round II, the panelists were also asked to rank "the top five biggest problems you believe university journalism programs will encounter during the process of introducing computer-assisted reporting courses." The respondents were asked to write "1" in the left hand margin of the list next to the biggest problem, "2" next to the second biggest problem, "3" next to the third, etc. All 29 respondents ranked the problem statements.

Table II lists the problem statements in descending order based on their overall ranking by respondents in Round II. First-place rankings were scored with five points, second-place with four, third with three, etc. When the point totals of two or more problem statements are the same, the statement with the greatest number of high rankings (# of 1st places or next highest) is listed first.

According to the Table II scale ratings, the most likely problems university journalism programs will encounter in the process of introducing CAR courses are cost of equipment, lack of qualified faculty, maintenance of equipment, class sizes limited because of equipment costs, and curriculum revision necessary for CAR courses.
According to the rankings, the problems of greatest magnitude university journalism programs will encounter are cost of equipment, lack of qualified faculty, maintenance of equipment, resistance of faculty, and resistance of university administrators.

Table III lists the top five most "likely" problems from the Round II bipolar scale ratings with the top five "biggest" problems from the Round II rankings. Interestingly, "cost of equipment," "lack of qualified faculty," and "maintenance of equipment," in that order, topped both lists.

Table IV lists the five problem categories in alphabetical order followed by their mean likelihood and magnitude scores. Overall, cost-related and institution-related were rated first and second both as most likely to occur and as having the greatest problem magnitude.

The use of computer-assisted reporting techniques is clearly an example of adoption of innovations, as DeFleur and Davenport pointed out. They concluded that university journalism programs in 1993 were noticeably "lagging" behind newspapers in their adoption of CAR [DeFleur and Davenport 1993]. The panel of experts in this study agreed. Further, they believe the gap between industry practice and university instruction should be closed. The panelists said problems associated with the introduction of CAR courses can be clearly identified and forthrightly addressed.

Table 1
Likelihood Ratings of Predicted Problems for University Journalism Programs Introducing Computer-Assisted Reporting Courses
N = 29

<table>
<thead>
<tr>
<th>Problem</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of equipment</td>
<td>4.138</td>
<td>1.145</td>
</tr>
<tr>
<td>Lack of qualified faculty</td>
<td>4.0</td>
<td>1.225</td>
</tr>
<tr>
<td>Maintenance of equipment</td>
<td>3.862</td>
<td>1.167</td>
</tr>
<tr>
<td>Class sizes limited because of equipment costs</td>
<td>3.586</td>
<td>1.350</td>
</tr>
<tr>
<td>Curriculum revision</td>
<td>3.586</td>
<td>1.427</td>
</tr>
<tr>
<td>CAR skills segregated in separate courses rather than taught across the journalism curriculum</td>
<td>3.483</td>
<td>1.353</td>
</tr>
<tr>
<td>Computer hardware becoming obsolete quickly</td>
<td>3.310</td>
<td>1.491</td>
</tr>
<tr>
<td>Resistance of university administrators</td>
<td>3.241</td>
<td>1.431</td>
</tr>
<tr>
<td>For purposes of promotion and tenure, faculty will devote time to research rather than learning new CAR skills for teaching</td>
<td>3.207</td>
<td>1.256</td>
</tr>
<tr>
<td>Students apathetic about CAR</td>
<td>3.138</td>
<td>1.457</td>
</tr>
<tr>
<td>Scarcity of CAR teaching materials</td>
<td>3.069</td>
<td>1.361</td>
</tr>
<tr>
<td>Faculty who misunderstand economic importance of CAR</td>
<td>3.034</td>
<td>1.017</td>
</tr>
<tr>
<td>Offering online services simultaneously to many students</td>
<td>3.034</td>
<td>1.426</td>
</tr>
<tr>
<td>The quality of retrieved data not being assessed</td>
<td>2.966</td>
<td>1.163</td>
</tr>
<tr>
<td>Resistance of faculty</td>
<td>2.966</td>
<td>1.322</td>
</tr>
<tr>
<td>Computer software becoming obsolete quickly</td>
<td>2.931</td>
<td>1.438</td>
</tr>
<tr>
<td>Developing new courses in statistical analysis for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem</td>
<td>Points</td>
<td>#1 Rankings</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>Cost of equipment</td>
<td>97</td>
<td>11</td>
</tr>
<tr>
<td>Lack of qualified faculty</td>
<td>67</td>
<td>9</td>
</tr>
<tr>
<td>Maintenance of equipment</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Resistance of faculty</td>
<td>27</td>
<td>3</td>
</tr>
<tr>
<td>Resistance of university administrators</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Class sizes limited because of equipment costs</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Students apathetic about CAR</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Cost of online time</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>CAR skills segregated in separate courses rather than taught across</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>the journalism curriculum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students intimidated by computers</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Curriculum revision necessary for CAR courses</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>CAR taught as a replacement for, not complement to, traditional</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>reporting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scarcity of CAR teaching materials</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>For purposes of promotion and tenure, faculty will</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2
Magnitude Rankings of Problems University Journalism Programs will Encounter During the Process of Introducing Computer-Assisted Reporting Courses
N = 29
devote time to research rather than learning new CAR skills for teaching 8
Computer hardware becoming obsolete quickly 8
CAR techniques becoming obsolete quickly 7 1
The quality of retrieved data not being assessed 6 1
Lack of standard computer hardware 5
Lack of standard computer software 5 1
Developing substantive student assignments 5
Limited number of student internships available in CAR-equipped newsrooms 5
Offering online computer services simultaneously to many students 3
Computer software becoming obsolete quickly 3
Faculty who misunderstand economic importance of CAR 2
Meeting expectations of incoming students exposed to new technology in high school and home 2
Developing new courses in statistical analysis for journalism students 1

Table 3
Top Five Problems by Likelihood Scale Rating and Top Five Problems by Magnitude Ranking
N = 29

<table>
<thead>
<tr>
<th>Problem</th>
<th>Scale Pts.</th>
<th>Ranking Pts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of equipment</td>
<td>120 (#1)</td>
<td>97 (#1)</td>
</tr>
<tr>
<td>Lack of qualified faculty</td>
<td>116 (#2)</td>
<td>67 (#2)</td>
</tr>
<tr>
<td>Maintenance of equipment,</td>
<td>112 (#3)</td>
<td>30 (#3)</td>
</tr>
<tr>
<td>Class sizes limited because of equipment costs</td>
<td>104 (#4)tie</td>
<td>26 (#6)</td>
</tr>
<tr>
<td>Curriculum revision necessary for CAR</td>
<td>104 (#4)tie</td>
<td>14 (#11)</td>
</tr>
<tr>
<td>Resistance of faculty</td>
<td>86 (#14)</td>
<td>27 (#4)tie</td>
</tr>
<tr>
<td>Resistance of university administrators</td>
<td>94 (#8)</td>
<td>27 (#4)tie</td>
</tr>
</tbody>
</table>

Table 4
Problem Likelihood and Magnitude Scores for the Five Categories of Problem Statements
N = 29

<table>
<thead>
<tr>
<th>Problem Category</th>
<th>Likelihood Mean Rating Pts.</th>
<th>Magnitude Mean Ranking Pts.</th>
</tr>
</thead>
</table>
Cost-Related 3.517 46.0
Curriculum-Related 2.953 8.4
Equipment-Related 3.165 19.0
Institution-Related 3.283 26.2
Student-Related 2.784 9.8

References

Garrison, Bruce (1995) "Computer-Assisted News Reporting Tools: A Study of Daily Newspaper Use," research paper presented at AEJMC Southeast Colloquium, Newspaper Division, Gainesville, Florida, March, 11. [Of the papers, 56.3 percent were under 75,000 circulation, 34.1 percent 75,000 to 300,000].
Peters, Nora (1994) Computer-Assisted Research: A Guide to Tapping Online Information, 2nd ed.St. Petersburg, Florida: The Poynter Institute, 2. [Garrison defines CAR as the 'use of computers to gather information for a news presentation.' He identifies two primary realms of CAR: online research, and database journalism -- analysis of created or accessed databases. Similarly, DeFleur and Davenport identify three major areas of computer use by journalists: searching public and commercial online databases, analyzing digitized government records, and creation of specialized databases].
Collaboratively-Created Multimedia Modules for Teachers and Professors

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An initiative was established to create instructional modules for K-12 teachers and university professors interested in learning how to utilize multimedia in the classroom. It is based upon the assumption that technologies in themselves do not automatically change the nature of teaching and learning. Rather, it is the way teachers integrate such technologies into curriculum. Equally important are the reasons such technologies are integrated into the teaching-learning process and how technologies fit into wider goals of education. There must also be a clear understanding of the benefits the technologies are supposed to produce, their educational value, and what type of learning is enhanced through which medium (White, 1989).

A two-year project funded by the US WEST Foundation focuses how to best use tools for education that combine quality technology with quality education. Surveys and focus group data indicate computer-based technologies now in our schools are under-used as tools for integrating the teaching-learning process. It was found that locally, approximately 60 percent of the teachers in the school districts, 40 percent of the education graduate students, and 50 percent of the undergraduate education students did not know how to use computer multimedia. Most who did used commercial products in very limited classroom situations (Stammen & Vetter, 1994).

Many teachers lack not only training in multimedia applications and forms of assistance this technology offers, but they do not have the time, resources, nor have they been given the opportunity to explore their creative capabilities. Those teachers who do implement such projects must work harder, concentrate more, and embrace larger pedagogical responsibilities to acquire considerable additional knowledge and skills to effectively use emerging multimedia technologies in their classroom. Once decisions are made to adopt and implement multimedia technologies for actual use in the classroom, there must be continued use or collaboration to reinforce the decision while it is becoming a real part of the teaching-learning environment. The faculty must be provided time and training to become comfortable with new procedures. Such teacher support rarely exists in school districts or in teacher education programs (StClair, 1989; Van Horn, 1995).

This project based at the North Dakota State University at Fargo is designed to provide such support. The goal is to enhance teaching through multimedia applications and network technologies, particularly through collaborations among the participating computer science departments, schools of education, and teachers in K-12 schools. The modules are being developed during the 1995-1996 school year to be piloted in classrooms during the 1996-1997 term. An important facet is that the implementation will be done by a statewide instructional service agency called the Center for Innovation in Instruction located at the Valley City State University. This agency has developed a cost-recovery program among school districts statewide which is necessary to sustain ongoing efforts beyond the grant life. Their inservice staff provides instruction in the classrooms of the teachers or professors who are participating in the training.

The following measurable objectives where devised in order to achieve the goal of developing products to enhance the teaching-learning process with multimedia applications and network technologies:

1. To develop competency-based training modules for preservice and inservice education utilizing a uniform procedure which enables teachers to incorporate new technologies through the use of a systematic curriculum and instructional development process
2. To design innovative multimedia materials and processes that have widespread interest and can be adapted for other classrooms and network-based delivery networks
3. To incorporate training into teacher education curricula to facilitate systemic change in colleges and universities
4. To provide models of learning that are enhanced by the introduction of using multimedia technologies for K-12 classroom purposes
5. To prototype and implement modules for all educational levels by a statewide instructional service agency which has a cost-recovery program necessary to sustain ongoing efforts beyond the life of this grant.

The project is unique because it is based upon the Systematic Curriculum and Instructional Development (SCID=A9, 1990) process created at the Center for Educational and Training for Employment at the Ohio State University. This process has been utilized internationally to help instructors, particularly in business and industry, develop curriculum instructional guides and training modules for inservice sessions or on-the-job training. The innovative aspect of this project is the adaptation of the process for a mix of elementary, secondary and postsecondary instructors and computer/technology specialists. SCID processes generally involve people who work in identical situations. The definition was generalized to include a broad range of educators who utilize computers for instructional purposes.

Five Phases of Project

This process is separated into five phases:

- **Phase I: Analysis** - uses needs analysis, job analysis, and task verification processes.
- **Phase II: Design** - outlines the overall curriculum and develops the foundation for the training program.
- **Phase III: Instructional Development** - determines what will be taught and what learning activities, materials, and instructional methods will be used; develops the modules which are comprised of learning guides including supportive multimedia methods; field testing; pilot testing and revision processes.
- **Phase IV: Training Implementation** - activates the training plan, its evaluation, and documents learner achievement.
- **Phase V: Program Evaluation** - evaluates each of the five phases, including product, phase, and process evaluation.

The project is currently in Phase III: The Instructional Development Process. The following information will review Phases I-III, what transpired in each phase of the project, and a review of the process.

The first objective of the project was to develop competency-based training modules for preservice and inservice education through a systematic curriculum and instructional development process. The Systematic Curriculum Instructional Development (SCID) model (copyrighted 1990) for curriculum development from the Center for Education and Training for Employment (CETE) at The Ohio State University in Columbus, Ohio, was chosen. The process began in Phase I.

**Phase I: Analysis Process**

A significant part of the instructional systems model is the analysis phase. The foundation for the planning and training activities is determined in this step. The purpose of the job analysis is to identify all of the crucial tasks performed by workers in a particular job; the workers are the teachers using multimedia to enhance their lessons in the classroom. The data obtained is used to design new occupational training programs or to revise and update current training programs. In a business environment, management can also use the information to write relevant job descriptions, determine work flow, and improve work efficiency and effectiveness.

The Developing A Curriculum (DACUM) method of conducting a job analysis has proven extremely successful for the Center for Education and Training for Employment. The DACUM philosophy places significant importance on using expert workers in an occupation to describe what tasks they perform. Two basic roles existed in this process: 1) those determined to be expert workers in multimedia and 2) a facilitator from CETE who collected the information and put it in final form.

Twelve local men and women were prudently selected to participate on the DACUM Panel. Each individual profiled expertise in different skills and competencies and were considered to be top performers in their area. To reflect the range of teachers who would eventually be involved in the training, the panel needed to represent a cross-section: elementary, middle school, and high school teachers; a university teacher educator; a university
multimedia coordinator; a technology trainer; a university student; a computer science professor; and two public school district technology coordinators.

After two full days, the panel of experts, under the guidance of a CETE facilitator, generated a DACUM chart—the product of the job analysis process. The chart encompasses a list of general task categories called duties and many tasks for each duty. In addition to the duties and tasks, the panel of experts also identified (1) general knowledge, skills, important worker behaviors; (2) tools, equipment, supplies, and materials; basic media skills; and (3) future trends/concerns that may cause job changes for teachers integrating multimedia into their curriculum and classrooms.

The DACUM chart, the duties and the number of tasks it encompassed, is listed below:

Duty A: Acquire Basic Computer Skills (5 tasks)
Duty B: Improve Curriculum with Multimedia (14 tasks)
Duty C: Deliver Instruction with Multimedia (11 tasks)
Duty D: Utilize Support Services (5 tasks)
Duty E: Improve Teacher Communication with Multimedia (12 tasks)
Duty F: Promote Multimedia in the Classroom (6 tasks)
Duty G: Pursue Professional Development (10 tasks)

Besides the twelve DACUM panel members, an additional thirty qualified individuals reviewed and verified the DACUM list of duties and tasks in a task verification process to determine the competencies needed by teachers who integrate multimedia into their lessons. The question they asked themselves when completing the questionnaire was, "Is this task actually performed by the teacher using multimedia technology?" A comment section was available following each duty. Once the DACUM duties and tasks were verified, it was sent to CETE where it was printed and returned for distribution to all personnel associated with the project.

Review of Phase I

For several years, DACUM has been effectively used to determine a job analysis. Expert workers are gathered to describe tasks involved in their specific occupation. Our panel of experts, though, was not comprised of expert workers from one specific occupation. The collaborative brainstorming to determine the duties and tasks confused them. The tasks for a teacher using multimedia in instruction had never been defined because no specific job existed. The process was stymied by the diversity of the participants' backgrounds and the logistics did not flow. After a half-day into the process, the panel was forced to change the question from, "What tasks do you perform when using multimedia technology?" to "What tasks are performed by the teacher using multimedia in the classroom?" As one panel participant stated at the end of the process, "I believe the initial listing of our roles in technology were off target from the focus of the project." Once the panel re-focused, the process went well. An exuberant exchange occurred between the people involved. The group dynamics was powerful and the energy-level was rampant.

The task verification instrument was sent to over 30 people. Their responsibility was to verify that the duties and tasks generated by the DACUM panel were valid for teachers integrating multimedia into instruction and to rate the importance and difficulty of each task. Confusion surfaced here, also, because of the lack of expertise in this specific job area. In the comment section, one person wrote, "This was a very difficult form to complete. In my opinion, it was too complex, too wordy, and I'm not sure how you can use this information."

Other significant comments and thoughts were presented through the task verification process. There was a feeling of excitement for what was to come with the project and many were extremely pleased about the collaboration between higher education and K-12 personnel. One participant suggested that provisions needed to be made to address the wide range of teachers who would be in the training: pre-school to post-secondary, experienced user vs. non-user, specific curriculum area, and individual teaching styles. A common theme in the comment section related to the time factor—the demand on a teacher's already too busy schedule to keep abreast of new technologies and applications. Another person advised that everything possible be done to make the multimedia technology training modules both appealing and teacher friendly. Concerns about copyright issues were also mentioned.

Phase II: Design
This phase involved 24 people who were trained by the Ohio State CETE personnel to use the SCID process. The SCID participants came from varied backgrounds: computer technicians, multimedia experts, curriculum developers, classroom teachers, teacher educators, students, administrators, and practitioners. Seven of the participants in the DACUM Panel were also involved with SCID.

After a five-day training session, the 24 newly trained SCID facilitators formed Design Teams to develop the Modules and Learning Guides for the competency-based curriculum. There will be seven Modules which reflect each of the duties: A-G.

Review of Phase II

Individual agendas had an affect on the group's direction. Some felt inadequate. One participant noted, "Since I did not have a focus until Friday, my contribution was marginal." Another person wanted to be involved in designing multimedia products, but had no framework or interest for curriculum writing. A teacher with interest in curriculum design said that she wanted to stay clear of the 'techie' stuff.

The process was an exercise in awareness and respect for each other's role and interest in multimedia. The participants were forced to think about issues collectively and support the direction of the project. A university professor in computer science confirmed, "It is important to develop new support service mechanisms for teachers who wish to get involved with multimedia in the classroom." He also acknowledged a greater appreciation for the K-12 teachers and their needs.

The enthusiasm and motivation was remarkably positive. An interesting bond developed and evaluations indicated a sincere appreciation for the collaborative teamwork approach. The diversity that made one part of the process a challenge, also opened the door to a refreshing professional networking system. The teamwork interaction and small group activities were considered "wonderful sharing experiences." One elementary teacher expressed that this was her most exhilarating professional experience.

Phase III: Instructional Development

This is the phase we are currently in at the time of this writing. This phase determines what will be taught and what learning activities, materials, and instructional methods will be used in the teacher training program. The program-based curriculum that was chosen focuses on the learner/trainee.

The modules (duties), which are comprised of learning guides (related tasks), will become the competency-based curriculum package. At the time this paper was written, the modules/learning guides were being drafted. A standard format, presented during the SCID training from the CETE facilitator, was established for all learning guides. This allows the designers to be free of routine decisions and they can concentrate on the content. The basic structure of the learning guide includes identifying the performance required, the conditions under which it will be performed, and the criteria or standard to be met. These learning guides are designed to be used independently.

When the learning guides are completed, the design teams will gather to validate the articulation between all the learning guides for each specific module. Naive readers will then read for clarity. Instructional design and competency-based authenticity will be evaluated. Technical designers will then be engaged for assessing multimedia applications, and networking connections. Field testing and pilot testing will complete the cycle in this ongoing refinement process.

Review of Phase III

The DACUM and SCID sessions were completed in June and July, 1995, when the participants' schedules were somewhat repressed. They had more freedom to gather and/or communicate. The lazy-days-of-summer atmosphere filtered into the environment. The thrust of the Fall agenda is challenging the design teams with many obstacles: incompatible schedules, distance, athletic coaching, and additional job-related demands.

Some of the learning guides clustered up to four related tasks. The time span from June to October diminished the clarity of the tasks written during DACUM. The design teams have had some difficulty interpreting the written tasks. Generally, a telephone call and five minutes of interaction will clarify the confusion. If necessary, we review the videotapes from the DACUM sessions when the tasks were stated.
The learning guides will be completed at the end of 1995. Before each one is submitted, the design team must complete a learning guide review checklist. This will assure that the intended design is internally consistent and delivers the intended objectives. Most of the refinements will be done after the field tests.

Multimedia was defined for the project as an integration of two or more media, electronic computer-based, which utilizes text, graphics, video, and/or sound to enhance the teaching/learning process. The partners in this endeavor agreed to establish a sustaining network to help educators acquire necessary education and training to use multimedia technologies to enhance learning in the classroom in ways to achieve the following desired outcomes:

1. Learn the fundamentals and varied multimedia options that are currently available for use in classroom environments. This includes learning how to use multimedia technologies along with the following fundamentals:
   - what to use these technologies for in the classroom and other educational settings,
   - when to use them for various K-12 levels and postsecondary settings, where to use them and where to obtain support and assistance whenever in need,
   - how to integrate these technologies in teachers' curriculum through teamwork, cooperative learning, teaching-learning models, strategies, learning styles, and the dimensions of intelligence,
   - and how to ensure gender and ethnic diversity and sensitivity to all cultures becomes an integral part of the teaching/learning process.

2. Learn how to develop or produce microcomputer applications or integrated programs which project interactive displays on a screen, classroom wall, or on a television monitor:
   - to present information in a classroom setting (presentation)
   - to create and/or develop hypermedia programs (assimilation)
   - to use authoring tools/applications for independent learning situations
   - to produce student/teacher projects, moving from these first three models to a "real work" model which encompasses: problem definition, resource identification, solution development, and peer reporting

3. Learn how to utilize computer peripherals such as devices for still-picture camera capturing, CD-ROMS, optical disks, or video-clip application programs.

4. Learn how to access on-line multimedia presentations over the Internet by utilizing computer-mediated communication client servers such as Telnet, FTP, Gopher, WAIS, World Wide Web (Mosaic), and accessing local area hosts containing CD-ROM or other multimedia-based files.

5. Learn how to utilize a combination of tools in an instrumented classroom using television monitors or distance education interactive-television classroom teaching stations.

The scope of work includes sorting out distinct differences in defining a multimedia project which will enhance the teaching-learning process in the classroom that take into account the following elements:

1. Establish a system whereby the multimedia modules addressing these learning objectives will adhere to adult learner characteristics such as acquiring and sustaining attention; assuring the project has relevance to immediate needs; instilling a sense of confidence and desire to stay involved; and promoting satisfaction through participation

2. Establish a system whereby multimedia modules addressing these learning objectives will be updated and kept current with new technological developments. This area addresses distinct differences in terms of technological difficulty in regards to beginner, moderate, difficult, and very difficult.

The SCID process (July-August 1995) ascertained the title and content of each module. September to December 1995 was utilized by two people teams for each guide. The following learning guides are scheduled for completion by June 1996:

Module A: Acquire Basic Computer Skills

Learning Guide 1 Obtain Basic Computer Training, Perform Basic Functions & Match Software
Learning Guide 2 Manage Computer Software
Learning Guide 3 Manage Computer Hardware
Learning Guide 4 Utilize Computer Documentation

Module B: Improve Curriculum with Multimedia

Learning Guide 1 Curriculum Evaluation
Learning Guide 2 Review of Multimedia Software/Hardware
Learning Guide 3 Identify Learning Activities, etc.
Learning Guide 4 Select Multimedia, etc.
Learning Guide 5 Modify Use of Multimedia, etc.
Learning Guide 6 Design Multimedia, etc.
Learning Guide 7 Evaluate Tryouts

Module C: Deliver Instruction With Multimedia

Learning Guide 1 Select Method of Delivery
Learning Guide 2 Setup and Verify System/Operation & Prepare Classroom Environment
Learning Guide 3 Introduce Multimedia Lesson
Learning Guide 4 Provide Direction and Practice
Learning Guide 5 Assess Performance & Effectiveness
Learning Guide 6 Develop Alternative Plan

Module D: Utilize Support Service for Multimedia

Learning Guide 1 Identify Need and Problem
Learning Guide 2 Identify Available Support Services
Learning Guide 3 Check Troubleshooting Guide
Learning Guide 4 Consult Local & Extended Resources

Module E: Enhance Teacher Communication With Multimedia

Learning Guide 1 Share & Display Information & Projects, Publish Newsletter
Learning Guide 2 Prepare Administrative Reports With Multimedia
Learning Guide 3 Create, Retrieve, and Prepare Assignments
Learning Guide 4 Retrieve and Create Student Assignment

Module F: Promote Multimedia In The Classroom

Learning Guide 1 Share or Present Experiences and Results
Learning Guide 2 Provide Assistance or Demonstrations

Module G: Pursue Professional Development Related To Multimedia

Learning Guide 1 Participate in Professional Development Activities
Learning Guide 2 Promote Professional Development Activities

The titles of each of these modules and learning guides illustrate areas the DACUM experts deemed important for educators when establishing ways to learn how to utilize computerized multimedia in the classroom. The modules products will be pressed on CD-ROM, and made available as Web Pages over the Internet via the World Wide Web (http://www.ndsu.nodak.edu/~stammen/uswest).

The mentors from the Center on Innovation in Instruction will provide the constructive support once their onsite teacher-as-students have mastered this process-based procedure. This support will enable the teachers and professors to develop the necessary strategies needed for their particular cognitive field of study.
North Dakota, one of the most rural states in the nation, has every school district accessed to a computer-mediated telecommunication network known as SENDIT. They are able to access either through 1-800 lines or dial directly to a node located at each county seat or university/college which connects to a statewide frame-relay network. The eleven colleges and universities and a third of the secondary schools currently provide interactive video (television) with two-way audio, video and multimedia capabilities.

Partners in the initial project are the 46 K-12 schools in the Southeast North Dakota (SEND) Technology Consortium, Schools or Colleges of Education at North Dakota State University (NDSU), Valley City State, and Mayville State, Center on Innovation for Instruction at Valley City, ND, NDSU Computer Science Department, NDSU Information Technology Services, and Tri-College University. Project Directors are Ronald M. Stammen, Ron Vetter, and Dan Pullen. The US WEST Project Evaluator is Lyn Foa, Former Deputy Director of the Annenberg Foundation.

References

Various broad factors which determine the basic characteristics of a piece of instructional software were investigated and applied to a prototype practice environment in Theoretical Computer Science. For each factor the most appropriate approach was selected and integrated into an appropriate life-cycle model.

**Life-cycle Model**

For Instructional Systems Development (ISD) evolutionary prototyping appears the most effective life-cycle model. [Black 1988] and [Wong 1993] advocate rapid prototyping for CAI. Initial parts of an envisaged system, once satisfactorily complete, can be used in the final product. FRAMES breaks new ground in the type of software developed at Unisa, a distance-teaching university in South Africa. A highly interactive and flexible practice environment entails innovative instructional strategies, calling for new programming techniques. Initially, even the technical feasibility of the desired features had to be assessed. The logical requirements were imprecise, and with the premise of form follows function, screen layouts needed to evolve. Wong's prototyping life-cycle, slightly tuned, is the ideal route, since it is conducive to modification of the approach, the strategies and even of the objectives.

**Requirements Analysis**

[Lantz - undated] compares logical definitions in software engineering (SE) to instructional objectives in CAI. Instructional objectives and requirements in FRAMES embrace the general characteristics, both instructional and computing-oriented of the problem area, namely the study of relations in Theoretical Computer Science for first level BSc students. Students require both the experience of studying worked examples and the opportunity to practice. The goal was to produce a practice-environment, an androgogic activity box providing a variety of useful instructional activities, in varied instructional modes, and to design and develop it using a software engineering approach.

Aspects of [Schiever 1991]'s thinking model are relevant to the instructional ethos. FRAMES should develop HOTS within learners [Vockell 1989], in particular metacognition. The instructional approach used is cognitive science, implemented with a constructivist flavour, viewing thinking and learning as human information processing [Newell 1972]. Important aspects are the integration of new information with old, limitations on STM, and [West 1991]'s cognitive strategies. Despite the cognitive approach, several of [Fleming 1978]'s behavioural learning principles are applied in FRAMES.

**Design**

Lantz also compared physical definitions in SE to instructional strategies (or modes) in CAI. FRAMES is not a tutorial, but an interactive learning environment, offering practice and perusal. In line with component display theory [Merrill 1983, 1988], learners select components from a variety of instructional transactions, the components being single tasks or complex integrated problems. A variety of examples and non-examples is provided. User-control ensures flexibility in sequence [Hammond 1992], content, strategy, and quantity. Help is available on request; cuing and prompting provide implicit guidance. FRAMES offers active engagement, including limited opportunities for creative synthesis. The major processing activities in ISD are the calling of components (either by the learner or by another component) and the assessment of learner-responses. Alternative
correct responses to questions and entries within proofs must be acceptable. This calls for effort in designing judgement and feedback modules, facilitated in FRAMES by a limited knowledge base.

For the development approach, referred to as courseware engineering, an object-oriented (OO) methodology was followed. The OO paradigm, viewing a domain as comprised of interrelated objects, is most appropriate for component-based instructional software and compatible with prototyping. The frames of FRAMES are not full screen presentations, but window-style components (objects), combining to form flexible screen displays with certain fixed functional areas.

Conclusion

The research and development of FRAMES resulted in a flexible and cognitive interactive learning environment, implemented by an object-oriented, component-based design and developed using a prototyping life-cycle model.

References


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Abstract: The Technology Rich Classroom (TRC) Project integrates computers used as a tool for learning with other strategies to meet the needs of all learners. A central feature of TRC classrooms are their multimedia computers integrated into regular teaching and learning activities. Technology-based projects engage and interest students, motivating them to commit to learning. The projects provide for connections between the disciplines of knowledge and to the students's lives. Students develop skills for problem solving, creativity, collaboration, life-long learning, and using technology through class projects. The project structure provides for individualized learning, varied time for instruction, and differentiated curriculum for all students. Technology allows students to work in and combine various media including sound, still graphics, motion video, and text. TRC teachers are exploring learning stations, cooperative learning, learning theories, interdisciplinary curriculum, project-based learning, and authentic assessment.

Introduction

It was a cool April morning, the Monday after the twenty-fifth anniversary of Earth Day, and more than 200 elementary students were excitedly moving from activity to activity at Lake George Regional Park. Students used empty plastic soda bottles to make planters, terrariums, and bird feeders. Other students played the games in the new environmental education building. Some were studying water from Lake George under a microscope. Still others were touring the new nature trail. The most exciting aspect of the day was that our 50 fifth and sixth graders designed all the activities, including the new nature trail and environmental education building. These students became involved with active learning through the Technology Rich Classroom Project.

Maine School Administrative District #54’s Technology Rich Classroom (TRC) Project is where we hope to create our vision for education. That vision is to make M.S.A.D. #54 a place where all students are actively learning and constructing their own knowledge, where educators apply research on learning and are themselves learners, where a developmentally appropriate education is provided for students, and where assessment strategies accurately detail what each student knows and can do. Over the last few years, we have seen the TRC project become a powerful catalyst for changes in teaching, learning, technology use, and teacher support and inservice.

One TRC Teacher’s Story

JoLynne Crout’s Fifth and Sixth Grade classroom in Canaan Elementary School became part of the TRC project in the fall of 1994. Canaan Elementary School, a K-6 school with 14 teachers, serves approximately 240 students. Canaan is rural, even for our district, and is largely composed of blue collar families who work in the woods or at local mills and factories. Here is JoLynne’s story of being in the Technology Rich Classroom Project:

It started with mukluks. I was involved with dog sledding and had just recently attended a meeting of interested mushers where I found a muklus catalog which included a centerfold about the International Arctic Project. It mentioned that there would be a team of six expeditionaries. What made me really enthusiastic about this is that it included two women. As a teacher, I admire women who go beyond the normal boundaries. It said that they were going to take a 2000 mile trek across the Arctic using canoe sleds and skis. One of my goals was to go on a trek across the USA, but this was more exciting!

The International Arctic Project had an environmental classroom component offered by World School. I called for the advertised teacher packet. When I received the materials, I discovered that my kids could be
involved in the project if they could get onto Internet. The project would include communicating with the expeditionaries and other students from around the US. Because of our isolated area, I felt it was important for my students to get exposure to other cultures and communities.

That fall, I had been chosen to be part of the district’s Technology Rich Classroom Project. We received a printer and two brand new Mac LC 550s with CD-ROM drives, but very little software. I participated in a two day orientation right before school started and as soon as we got the new equipment, we tore open the boxes and punked! All I had before were two outdated Apple Ile computers, which still break down when the wind blows. I wasn’t really sure how to use our new computers, but knew that my kids could help. Andy, one of my students who had a Mac at home, became my first computer expert and offered to help. One of his first actions was to give me the manual and tell me quite firmly that I had a month to learn everything in it! Whenever the class tried something new that we could not figure out how to do, we’d call Andy to come and show us.

I had to learn from working on my own computer at home, which was mostly used by my 16 year old daughter. The computers at school were used by students the whole day and I couldn’t get on them until long after school. I decided we needed to train kids to train other kids. Andy trained the first group, and slowly we learned how to use the few programs and CDs we did have.

Later in the fall, I was able to sign up for a Technology Rich Classroom course. One of the instructors was the Middle School’s Computer Resource Specialist, Mike Muir. The course gave us an opportunity to play around with the software, to see how group dynamics worked, and how I could apply it back to my classroom. It showed me that two computers could be used by six people working cooperatively on a project. The course presented a project-based model for curriculum development, including the use of learning centers.

I had tried centers the year before and it had bombed! I tried to put my finger on the cause and what I discovered was that it was the technology that was missing. Using the computers provided an extension to students’ knowledge. Just being able to access information on the Grolier’s Encyclopaedia CD opened up whole new possibilities. Learning centers had been really hard to do because the information just wasn’t there and students didn’t want to take the time to look it up, or it was old and outdated information. Being in an isolated area, it was difficult locating resources. I had spent thousands of dollars of my own money to buy books so kids would have good resources for their projects, but the technology provided up to date information which could be located quickly. Students could see it, they could access it, they could find it on the computer in a way which would make it real to them. On the computer, they were in control of their own learning.

The format of the TRC course allowed for individual preference for what we wanted to learn. If we wanted to spend 6 weeks surveying software, we could do that. If we wanted to preview CDs, we could do that. There were also minilessons for interested teachers to learn about other equipment, like the scanner, the modem, and the QuickTake camera. Becoming aware of what was available was helpful because then I knew what to request in a budget, or from the district coordinator for preview. The instructors asked the participating teachers what minilessons they wanted and involved the teachers in decision making about format and objectives for the course. That meant that we were free to learn what we wanted to learn. Because I could focus on what I was most interested in, it was the easiest class I had taken and the most fun!

From the format of the course, my own style of teaching evolved. Everything I learned in that class I took back to my own classroom, because I had seen that others had tried it and it worked. I adapted it to my own style and fine tuned things I already did. Between things I had already done in my class and what I learned in the TRC course, I knew I could do learning centers, design projects which addressed our curriculum, and give students choices about how they would learn. I decided to tackle these ideas through the International Arctic Project.

Dave Person, the district computer coordinator, provided the subscription fee to become part of the project. That told me that he trusted my ability to carry it out. He also promised to have a phone line installed so that we could get onto Internet. We waited many weeks to get the phone line and when it was finally installed, the administration placed a long distance block on the line. There is no local access to Internet in Canaan, so even though we had the phone line, we could not carry out that part of the project in the classroom.

The International Arctic Project has three components. Students could follow the Arctic expeditionaries through their daily reports posted on Internet. Using the net, students could also ask questions of the expeditionaries about their trip and the research they were conducting on pollution levels in the Arctic. The second component was conducting a local environmental education project. This could be classwork or a larger, community-based project. The third component was being connected through the Internet to other educators who were part of the project. There were four other schools participating and we shared ideas and the results of our local projects. Through St. Thomas University in Minnesota, who was coordinating World School’s International Arctic Project, we had access to graduate students who helped design related classroom lessons and activities, and also to experts on the Arctic who could help answer students’ questions.

This required a great deal of telecommunicating. The computer coordinator tried to find ways that he could provide local or inexpensive Internet access, but none of the options worked out. Mike Muir, who provided TRC classroom support in the afternoons after the Middle School let out, tried what he could to get our
classroom computers connected, but to no avail. I was stuck with doing my telecommunicating from my home computer. The enthusiasm the project generated in my students more than made up for my long-distance phone bills.

Students and I brainstormed environmental activities, then spoke with officials at our nearby regional park, finally deciding on several projects: an environmental education building and nature trail at the park, planting flowers and trees at the park and school, a vegetable garden, and recycling and composting endeavors at the school. My students developed their plans, then presented them to the Board of Directors of Lake George Regional Park. The board became enthusiastic and eagerly supported our ideas. Students, divided into subcommittees, dove excitedly into the projects. When someone entered our classroom, they might have thought it was chaotic, but it was not. If they had spent time there, they would have seen it was meticulously organized and that students were thoroughly engaged.

Part of the challenge to teachers is creating environments which are rich enough in resources that students can take from it what they are most interested in. Having lots of resources does not have to mean lots of money. We used tool software flexible enough to meet many working and learning styles, books borrowed from libraries around the state, and supplies consisting mostly of recycled materials. Technology extended our resources. Ten year old conventional encyclopedias in our school are outdated. CD-ROM encyclopedias and Time Yearbook discs provide the latest information. Internet gave students access to new research that was literally hours old.

Some of the individual environmental projects were truly amazing. Billy and Sally created an oil spill simulation and dipped various “animals” in the spill to show what effect it would have. Donna compared various states’ pollution levels to Maine’s. Ralph and Susan created an oil spill in a bucket and tested the effectiveness of various materials on absorbing the spill. Students created a rain forest complete with (nearly) full sized trees, plants, and animals. One of the most interesting projects was constructed by Nate and his family. He created an erosion simulation by building a slanted table, filled with sand, and connected to a fish tank which pumped water down the slope.

On the Monday after Earth Day, packed with my student’s individual projects, we opened our new Environmental Education Building at Lake George State Park.

The Technology Rich Classroom Project

M.S.A.D. #54 serves approximately 3300 students in Skowhegan, Canaan, Cornville, Norridgewock, Mercer, and Smithfield; towns in rural western Maine. Computer equipment in our 8 elementary schools is centered in our TRC classrooms. There, through project-based assignments, small groups of students are assured several computer experiences each day as they move around the classroom to diverse computer and learning stations to research, organize, interpret, and present information. These classrooms provide a significant increase in resources over traditional classrooms and create an instructional setting where knowledge and “doing” are powerfully linked. There are currently 31 Technology Rich Classrooms, approximately 37% of all K-6 classes. Every school and every grade level has at least two classrooms part of the TRC project.

The TRC Project began during the winter of 1993 in four classrooms as a pilot project funded by Chapter II. At the end of that year, the project was evaluated by Chapter II, receiving favorable reviews. In the fall of 1993, 10 TRC classrooms were added, providing representation at every grade level (K-6) and every elementary school in the district. In the 94/95 school year, the district funded 17 additional TRC classrooms. We are learning that technology can serve as a critically important resource for creating powerful, meaningful, and authentic contexts for learning.

The vision for TRC classrooms provides a learning environment which meets the learning needs of all students. Technology-based projects engage and interest students, motivating them to commit to learning. The projects provide for connections between the disciplines of knowledge and to the students's lives. Students develop skills for problem solving, creativity, collaboration, life-long learning, and using technology through class projects. The project structure provides for individualized learning, varied time for instruction, and differentiated curriculum for all students. Technology allows students to work in and combine various media including sound, still graphics, motion video, and text.

Technologies vary according to school and grade level, but each TRC classroom has a printer and two to four color Macintosh computers, at least one equipped with a CD-ROM drive. The approved district goal is to reach a student/computer ratio of 4:1. Although well short of that goal, our current K-8 student/computer ratio is 11:1. The district has additional peripherals, including a laser disc player, color scanners, two digital cameras, and a video digitizing station, which are shared among the schools. Some classrooms have phone lines for telecommunications, but, as stated earlier, the district maintains a long-distance block on those lines. (Toll-free telecommunications access in our area is extremely limited.)
How TRC Is Impacting Students

A major infusion of divergent technologies into a classroom offers an opportunity to rethink traditional practice, and can lead to changes in teaching and learning. In the more successful TRC classrooms, we have seen the following shifts:

• from whole class instruction to small group instruction
• from lecture and recitation to coaching
• from only a few students getting attention to all students getting attention
• from passive students to engaged students
• from assessment based on test performance to assessment based on products, progress, and effort
• from a competitive structure to a cooperative, social structure
• from students all learning the same things, to learning different things
• from verbal thinking to the integration of visual and verbal thinking.

Some of the teachers in this project have been very successful in meeting the diverse needs of students. The TRC project’s greatest impact seems to be on students with learning differences because of the visual nature of working with the computer. QuickTime movies and recorded speeches brought learning to life for many students. Seeing unfamiliar animals move on the screen or hearing Martin Luther King, Jr., give a speech makes them more real to students. Further, computers provide visual cues to students who are nonreaders, allowing them an avenue to success. The computer also allows students to work in visual media and we have seen reading come slowly to students who learn first to express themselves in another medium. Further, we have often seen a role reversal between what have traditionally been successful and unsuccessful students. Many of our “non-academic” students show successes creatively or through visual media, skills many of our “academic” students seem to have difficulty with. These two groups of students, who normally do not talk with each other, end up forming a friendly and productive alliance, sharing knowledge and skills.

The technology has also proved itself a self-esteem builder because there is no failure. A computer is a piece of equipment that does not tell students what to do, they tell it what to do; they are in control. Computer-based resources also put students in control of what they are learning and tool software, such as Kid Pix, HyperCard, and ClarisWorks, place students in control of how they share that information with others.

The project-based approach and rich collection of computer and non-technology resources allows for diverse students to work successfully. Our experience is that it is very difficult to keep everyone at the same level of learning for consistent whole group instruction, but having numerous varied activities allows everyone to work at his or her own level and in his or her own learning style. It also frees us to work individually with students. We have found that when students are at learning stations, learning what they want to learn, they take off and fly! In fact, most students’ projects and presentations, seemingly regardless of student ability level, are of the same high quality. During a recent Jigsaw activity, it was impossible to tell who were the special needs students and who were not. When our class presented their ideas to the Lake George Board of Directors, some of the best presentations came from students who have not traditionally been successful in the classroom. We have numerous examples of students finding new success through the TRC project:

• John, an unmotivated student did an outstanding report on scorpions. While looking through Boys Life for information about hunting, he came across an article on scorpions, and fell in love with the topic. His attitude quickly changed from apathy to hard-worker as he dove into researching his topic and creating his report.

• Allison, who reads on a first grade level, can word process her own reports after someone reads her new information. Amazingly, she can read any information she types herself. She also learns the material well and has demonstrated her self-confidence as a teacher. Allison ran the environmental education building on our opening day.

• Lisa is a potential drop out student. She has shown a great deal of computer expertise and we groomed her to be one of our student computer experts. Since we started working with her, her attendance greatly improved. She even stayed in school the entire day, waiting for training in new computer skills during the last period.

There also seems to be fewer behavior problems in TRC classrooms. We believe that the rich learning environment and building on student interests are responsible for this shift. We teach the students conflict management skills and students must solve their own problems, with our guidance. Project work and learning stations free us to talk individually with students when the need arises. Even students who usually provide the most severe misbehavior can be redirected with a minimum of effort.
Feedback from parents has been phenomenal! It is because of their support and desire to have their children in the program that we have increased our technology budget in tight economic times. The community and school board supported our efforts with a 50% budget increase for hardware and software for 94/95. The presence of these technologies symbolizes change for students, parents, teachers, and the community. New technologies are one of the most visible and obvious manifestations of how the world has changed and how quickly it continues to change. It was only severe funding shortages for the 95/96 school year which forced a cutback in resources and put a halt (hopefully only temporarily) to expanding the project. Even so, there is enormous pressure on administrators as parents demand that their children be placed in TRC classrooms.

One of our favorite indicators of the educational and academic success of this project came from Lake George State Park’s ranger. He commented that he never worked in groups as a student and, in fact, found teachers to be intimidating. “I’d love to be in your classroom,” he said, “The atmosphere is more relaxed, but the expectations are higher and the work is more interesting.”
Implementation of an Advisory System for On-The-Job Training of Printers

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Abstract: Based on a demand in the production environment of the printing industry, an information system has been developed which combines diagnosis and hypergraphic learning. This system’s unique functional capability of constructing a versatile knowledge base via interactive visual objects, including the results and the key points in its development, will be presented here. A diagnostic net, a hypergraphic information structure, and their combination, together with the advantages of graphical tools for development of complex and interdependent system components, will be demonstrated in this paper. Two benefits should be mentioned: the return on investment, and the on-the-job training of operating personnel.

Introduction

To achieve top quality and highest efficiency, the printing industry is constantly looking for the best professional education, newest techniques, applied knowledge, and practical experience with new production processes. FOGRA’s role is to enhance the need for professional experience through the transformation and dissemination of scientific results into technical developments, and to link scientific research with production needs. FOGRA is funded by members of the German and International Printing Industries, Federal and State Ministries of Economics, and the German Printers Association.

Since early 1990, intense discussions between FOGRA and the German Printing Industry about intelligent information systems and their implications for the printing industry resulted in a wide range of projects [1, 2, 3, 4, 5, 6, 7].

During the project’s definition and description phases, it became apparent that if an information system was to be accepted and used by professionals in production environments, it needed specific characteristics. For the common user, without computer literacy, these were:
- ease of use,
- an interactive and intuitive graphical user interface,
- explanatory graphical help and information system,
- a system, useful for the production environment, as well as for educating apprentices and new, or promoted, employees.

For the detection of faults in printing and related processes. And the third, to detect possible knowledge gaps related to the printing process, process components, and personnel training.

The result - a development environment where the domain knowledge was designed, and was structured interactively by graphical objects. This was a completely different approach from that suggested by previous authors, who based their concepts on tools like hypercard [12, 13].

The resulting user-oriented concept, consists of two different aspects of user guidance. The first is a diagnostic session where the system is the active, goal driven part. Here the user is the more passive component, supplying only the information requested by the diagnostic system. In the second aspect, there is an advisory mode where only hypergraphics are present. Here, the user takes control of solving the problem by requesting information. In this case, the system is passively waiting for user requests or actions.

The first aspect is achieved by creating several different diagnostic structures where information and knowledge of production processes are collected. A main base-structure contains all fault-related information, where the
type and category of a fault is diagnosed. Then, related sub-structures for that diagnosed fault-type are loaded, and the final cause can then be diagnosed. These sub-structures include: the evaluation of severeness of a fault, advice for quick remedies, and, in severe cases, advice for filing complaints with suppliers.

The second aspect is accomplished by creating related hypergraphic nets, including all the fault types, their relationship to the steps of the production process, and their final causes. These structures are linked to corresponding sub-structures and are activated when a fault is diagnosed. If a user suspects a specific cause, or fault, and does not need a diagnosis, he can access these structures independently. Therefore, the hypergraphic nets can be used as a separate source of information. The advantages of this concept have been proven in both presentations, and in user sessions of test runs.

Based on literature and the expertise of FOGRA specialists [14, 15], the most common faults were selected, and then a symptom-dependency structure was created. The basic concepts of this system’s structure is presented in figure 1.

System Development and Implementation in Production Environments

The majority of printing companies in Germany - in comparison to international standards - possess both efficient and modern production facilities. These high standards are possible because of regular financial investments. For example, statistical figures for the past 7 years revealed that the average investment in all production facilities ranged between 6% to 8.4% [16]. For small and medium sized enterprises, this leads to a yearly maximum investment of DM 814,000, and an average of DM 140,000 overall. However, investing in this manner, in an independent system’s development (including the related costs) would obviously be out of question for this kind of industry.

A project estimation of an advisory and training system for detection of faults in printed sheets [5], produced overall costs (including the hardware, system software, and the personnel costs for development and implementation) of about DM 400,000. This is far too high for any small or medium-sized enterprise Even though hardware and software costs are constantly dropping, the average still remains between 10% and 25% of the overall project costs. Final cost-related assessments of this project revealed that even the core development costs ran up to about DM 150,000. Even these would exceed any acceptable financial frame for a small enterprise. Consequently, a different approach to development was chosen. FOGRA acquired funds to develop an advisory system which was structured appropriately for the needs of industry, and which also contained all available FOGRA expertise. This base structure was made available to any printing industry enterprise, for a
nominal fee. Any adaptation to specific company requirements could now be done at a fraction of the initial development costs, thus, significantly reducing the risks involved for any individual printing industry enterprise.

Cost Benefits of an Advisory System for the Printing Process

In the German printing industry, production costs show that 34% is material related, while approximately 35% is attributed to personnel costs [16]. The results of another publication [17] showed that, even for large corporations, there is no generalised way of estimating the economic benefits of intelligent information and advisory systems. Consequently, these benefits must be estimated in domain specific areas, calculated according to specific implementations, and then achieved in these areas. The printing industry can be taken as a role model for any industrial branch which consists of small-sized enterprises. There are several possible ways of achieving economic benefits, but due to product versatility, they are not very obvious. In general, the most rewarding cost savings are related to: material consumption, reduction of material waste, reduction of machine down-time, increase in productivity, reduction of maintenance costs, avoidance of customer complaints, and the filing of successful complaints with suppliers.

Printing material consumption, and machine down-time due to cost structure, are significant areas for economic benefits. These areas will be presented in a detailed example. The calculations are based on data which is available for a four-colour printing machine. The parameters and average costs are based on other publications [18, 19, 20].

Savings on Material Consumption

Material consumption can most easily be measured by a sheet count on a print run. Here, the standard of quality control requires that one sheet in every thousand has to be picked from the delivery stack and checked. When a printing machine runs at a speed of 10,000 sheets per hour, this equates to a quality check at least every six minutes.

Selection of the sheet, transport to the control booth, and a visual inspection, require an average of one minute. Densitometer measurements, if necessary, can take an additional minute. In case of an unexpected appearance in the print, or the observation of a fault, an inspection by a second printer or a supervisor is required. This inspection can take, on average, four to five minutes. Usually, additional sheets are also picked from the delivery stack and inspected as well. Another two to five minutes may pass until a decision can be reached. Finally, when the first counter measures are launched, an average of seven to twelve minutes may pass, and then another two to six minutes until the fault has finally been eliminated.

This fault scenario would calculate as follows:

5-6 minutes = 1000 sheets - printed while fault not detected
7 - 12 minutes = 1170 sheets - evaluation and decision making (2000 sheets in worst case)
2 - 6 minutes = 330 sheets - for counter measures (1000 sheets repeated counter measures)

In this case, the printer has to sort out 2500 to 4000 sheets and reprint them. The related costs range from DM 1250 to DM 2000, for low grade paper; or DM 2500 to DM 4000, for high grade paper.

The implemented advisory system of problems in print was designed and developed as an off-line system. Consequently, its primary use was intended to speed up decision making, and to give advice on the fastest machine adjustment. The time from first detection of a fault, up to the launched counter measures, could be reduced to an average of 2-4 minutes, plus one minute for sample selection, and then transportation for inspection. Usually, the first machine adjustments should solve the problem and the fault should be instantly eliminated. When the diagnostic session and the results were documented by the system, it was possible for the printer to follow the system’s advice without the consent of the supervisor or the second printer. This led to significant savings due to reduced waste and unnecessary reprints.

These can be calculated as follows:

5-6 minutes = 1000 sheets - printed while fault not detected
3 - 5 minutes = 450 to 780 sheets - inspection and consultation of advisory system
2 minutes = 330 sheets - for counter measures
Consequently, the printer has to sort out only 1780 to 2110 sheets and reprint these. The related costs range between DM 860 to DM 1055, for low grade paper, or between DM 1780 to DM 1890, for high grade paper. For a single case the savings ranged between DM 390 to DM 945, for low grade paper, or between DM 720 and DM 1890, for high grade paper.

This type of print problem generally appears several times a week. With difficult or high priority and high quality print jobs it may appear several times in one shift. Therefore, an average monthly material-related savings of 5% ink reduction, 1% paper reduction and 5% plate reduction, can be expected. Total savings on this alone can be up to DM 17,000. If any costs due to loss of customer orders, customer complaints e.g. were to be included, savings would increase even more.

Machine Down-Times

The second area in which good cost benefits can be found is in the reduction of machine down-time. Down-times due to severe faults are just as common as the previous scenario. In the previously calculated material savings, it was assumed that a fault, which appears in a printed sheet, can be corrected through adjustment of printing machine parameters while the machine is not stopped. In many cases, the adjustment of the printing machine parameters does not help at all, or may even damage the machine, the printing plates, or the blankets. In those cases, the print run has to be stopped as soon as possible and the appropriate adjustments can take quite some time. A printer will usually avoid all unnecessary print stops as this would prolong the time needed to finish a current job, and simultaneously, delay all successive print jobs.

The average machine down-time costs on a four color machine will be about DM 456 per hour, or an average of DM 7.60 per minute. After every stop, a restart of print consists of another 200 sheets, with poor print quality, until print conditions are again stabilised. These sheets must also be sorted, adding further to production costs.

One of the most common reasons for down-time is plate and blanket cleaning. When the plate or blankets of a single unit have to be washed, the cost is DM 53.10 per unit. If cleaning is not carried out at all, there will be an abrasion effect appearing on the plate, and within a couple of thousand sheets, the plate will be blinded. In addition, a blanket embossing can occur, damaging the blanket, as well. Replacement of the plate and blanket can cause an even longer down-time, adding costs of DM 167 per printing unit, plus DM 860 per plate, and DM 180 per blanket. If a replacement plate is not readily available and has to be developed, it may take even longer before the print can continue. The total replacement of plate and blanket increases costs by DM 1207.20 per unit, which equals DM 4829 for the whole machine. Prevention of a single down-time due to plate abrasion (including job rescheduling and restarting an uncompleted print job), constitutes savings between DM 1000 and DM 3000 DM. Furthermore, down-time reduction of a single, unnecessary machine stop per shift (like washing), results in savings of DM 15,922.50 per machine, per month.

Summary

The combined structural implementation of a diagnosis and a hypergraphic system lead to increased speed in acquisition, design and validation of the base structures of the advisory system. The main reason being the interactively-manipulated graphical objects during the development stages. The graphical design supported construction, modularisation, and redesign of the base structures. In addition, it supported transparency of underlying knowledge, and gaps in existing or documented knowledge became visible in the graphical structures.

It also can be stated that the presented concept of an advisory system has proven its financial benefits in regard to this very specific business environment. Specification of the business environment is a prerequisite for success in small and medium-sized enterprises. In addition, the possible savings have to be estimated ahead of time and need to be significant. Budget constraints, even in medium-sized companies, allows for costs related only to modifications of advisory or intelligent information systems where the knowledge can be adapted to company-specific requirements, run-time or to up-dating. If costs can be kept as low as possible small companies will accept intelligent information systems. Only under these circumstances can these systems be beneficial for such enterprises. For them, the return-on-investment predictions have to be task-oriented and production-
process-specific. Correct evaluation of return-on-investment is only possible if benefit predictions are adapted to individual business environments.

Estimations of benefits for medium-sized print companies have to be based explicitly on reduction of material, waste and down-time. Each is linked directly to professional on the job training. That is an ongoing and never ending process due to technological changes, personnel fluctuation, etc. In a situation in which estimated savings cannot constitute a worthy return-on-investment, additional savings in increased productivity, maintenance reduction, and fewer customer complaints, have to be taken into consideration as well.

In the presented paper, and based on the structure of the advisory system, any savings on materials and down-time are significant enough to justify a system implementation. In some cases, savings can go up to DM 300,000 per year for a single company. If applied to large scale operations the savings can increase even more.

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Obstacles in Web Multimedia Publishing: Bringing Conference Proceedings On-line

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Abstract: This paper highlights the problems associated with placing technical multimedia materials on-line on the World Wide Web. It discusses obstacles in (a) automating the collection and processing of the multimedia components, and (b) limitations in the interface design imposed by restrictions associated with continuous media and especially audio. Using as paradigm the publishing of multimedia technical conference proceedings (“DAGS’95 Conference on Electronic Publishing and the Information Superhighway”), the paper proposes a manageable framework for the production of such proceedings, one that allows parallel development of the submitted papers in hypertext format and of the time-based media (talks) in multimedia format.

1. Introduction

The aim of this paper is to analyze the obstacles in placing technical multimedia materials on-line on the World Wide Web. Technical materials, as opposed to other multimedia applications, involve complex visual components such as, proofs of theorems, flow-diagrams, equations or statistical tables, i.e., interactive multimedia components that the user may wish to interact with as separate entities or retrieve or reference them separately from the rest of the application. Taking as example the papers presented at a computer science conference, “DAGS’95 Conference on Electronic Publishing and the Information Superhighway”, our primary objectives are to see how to (1) automate the task of collection and processing of the multimedia components, and (2) overcome the limitations in designing the web interface, due to restrictions associated with continuous media and especially audio. As a result, we suggest a framework that, as a first step, identifies ways to segment the tasks involved into independent components that can be produced in parallel. In the conference proceedings case, the development of the submitted papers in hypertext format can be done in parallel with the processing of the time-based media (talks) in multimedia format.

Using interactive multimedia conference proceedings to study multimedia development on the web allows us to examine a broad range of research topics in the field of hypermedia publishing. For example, it permits us to study ways of substituting for the multidimensional nature of human intercourse during a conference by designing user interface abstractions which are: (1) economical in the web sense (low bandwidth requirements, fast assembly or authoring), (2) cost-efficient (high content throughput versus time of use) and (3) have an attractive presentation interface. Furthermore, this paradigm offers us the opportunity to study similar issues arising when transferring multimedia materials embedded in CD-ROM onto the web.

The paper traces three generations of technical electronic publishing we have been involved with that identified trade-offs and user interface restrictions necessary for the web version. Since 1992, we have been building a series of electronic proceedings for the DAGS (Dartmouth Institute for Advanced Graduate Studies) conferences: The DAGS’92 Conference on Parallel Computing [Gloor 93] on CD-ROM, the DAGS’93 Conference on Parallel I/O on CD-ROM, the DAGS’94 Conference on Parallel Programming Environments on the web and the DAGS’95 Conference on Electronic Publishing and the Information Superhighway [Ford 95] on the web. The DAGS’93 and DAGS’94 proceedings extended the simple navigation system of the DAGS’92 digital talks, while the DAGS’95 proceedings simplified the interface in order to provide networked access to multimedia (audio/video) presentations on the web [URL http://awi.aw.com/DAGS95].
2. The Obstacles

The production of electronic conference proceedings is not a new idea and the benefits of searching, manipulation, etc. are obvious. The first electronic proceedings appeared in either CD-ROM or on-line format and were restricted to offering printed documentation in electronic form. Later on, new interfaces for retrieving and searching papers have been implemented and a variety of proceedings, such as e.g., the ACM’93 Multimedia Conference Proceedings implemented on CD-ROM [Rada93], and more recently, the ACM’95 Conference on Human Factors in Computing Systems [Mack95] (http://www.acm.org/sigchi/chi95/Electronic/documents/top.html). Of interest is also Deborah Estrin’s web talk on the Internet University (http://town.hall.org/university/network/estrin).

In general, reusability, portability and fault tolerance of multimedia components of an application are still hard to define, encapsulate, program and automate. One can identify two common weaknesses among the available multimedia conference proceedings:

- The network bandwidth is still considered too narrow for transmitting video or audio versions of talks over the web. Although the audio track can be broken into separate clips each belonging to one slide of text presentation, these clips are still prohibitively large for downloading over a modem connection (Estrin’s talk illustrates these shortcomings).
- Conferences present new results, and therefore timeliness is a very important requirement which necessitates the development of new methods for speeding up the multimedia proceedings development process. Unfortunately, it normally takes a very long time to develop multimedia versions of conference proceedings which are not mostly scrolling text with separate video segments.

Our work on the DAGS multimedia conference proceedings series addresses these shortcomings. In section 3 we describe the DAGS’95 user interface design. We then outline the creation process for the DAGS’95 multimedia talks, and illustrate how the production process can be automated to achieve a significant reduction in turnaround-time.

An important prerequisite of web multimedia publishing is the ability to interact with the multimedia data in an integrated user interface. While our first generation of multimedia conference proceedings on CD-ROM (DAGS ‘92) [Gloor 93] offered powerful and sophisticated random access features for navigation and searching, that interface required the user to jump from hypertext (the written papers) searching mode to continuous media mode (the actual talks). Similar random access features which enable the user to jump to a highlight within a speech have been integrated into the user interface for the DAGS’95 talks on the web. At the core of the DAGS’95 proceedings is the talks user interface (Figure 1). This figure shows that the talks interface has been reduced to a view of synchronized slide images combined with audio of the speaker’s voice (rather than offering video of a gesturing speaker), without substantially compromising the overall experience of the talk.
3. The Web Bandwidth Obstacle: Dealing with Audio and Images

Dealing with limited chunks of audio is still the only realistic continuous media approach for web access. Due to the limited network bandwidth available on the web, it is important to avoid forcing users to download huge sound files, something which may make an application unusable. It is obviously impractical to store entire files since the size of the sound of an uncompressed 30 to 45 minutes sound file digitized in low quality 8kHz “AU” format can easily take up to 40 MBytes. To address this problem, digitized talks have been offered as one large sound file per slide (e.g., Estrin).

We suggest to further refine this approach. In the development of the DAGS’95 conference proceedings, the audio files were cut into 200-300 KByte pieces. Restricting the average file size of the audio clips to 200 kilobytes implies that transmission via a 14400 baud modem should generally take less than two minutes. This means, that frequently the sound track belonging to one slide had to be broken into multiple sound clips. Given the common transfer rate achievable for modems we nevertheless expect modem users to employ the “listen to audio” feature very selectively. However, the trade-off here was that avoiding chopped sentences required intensive human post processing and defining all sound-clip boundaries manually. The target duration of the available audio clips was set at 40 seconds. As there were different factors to consider in the audio editing process (see point 4 in the next section), the audio clip size varies considerably.

Dealing with the graphical layout of the interface represented another interesting obstacle imposed by the limitations of HTML. To implement the control panel at the top of each slide, we were initially planning on having a basic background while the button set and the text label would have been overlaid for each slide. This would have allowed for caching of the imageresources such that moving to a different slide would not have required loading a new GIF file for the control panel. Unfortunately, we found that our ability to control detailed formatting information with HTML was too limited. Therefore we opted for a “one control panel per slide” approach. This required to keep the control panel very small such that the download speed for new slides would only be marginally affected by also downloading the control panel for each slide.

We first considered to convert text-only slides to HTML format, as this would have offered the best download performance. On slides with figures and other complicated graphics those would then have been inserted as smaller GIF files. We soon discovered that this approach would have prohibitively increased the complexity of creating WWW proceedings. We therefore decided to show all slides as images because this allowed us to retain the graphic quality of the overhead transparencies without additional editing.

4. Web-Authoring: Basic Tasks

The basic design process of the web-based DAGS’95 proceedings was very similar to the one for the DAGS’92 CD-ROM proceedings [Cheyney 96], although some details had to be refined due to improved video processing technology, limitations in network bandwidth and previous experiences with DAGS’92 and DAGS’93. The numbering in the following sequential description of the creation process corresponds to the graphical representation of the process in Figure 2.

1. Collect material:
   Each talk was filmed with HI-8 video. Based on previous experience we made a movie not of the speaker, but of the slides or transparencies. The audio input was taken from a microphone that speakers were requested to carry. Speakers had previously been asked to give us a slide set after the talk, preferably both in paper and electronic format. Slide originals were collected from the speakers after the talk. Last minute corrections or annotations by the speakers could also be included this way. The slide formats included handwrittenslides, color transparencies and files produced by presentation programs.

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1 The use of proprietary compressed audio file formats such as RealAudio [RealAudio 95] allows to change the design of the audio part, as it permits real-time continuous download. RealAudio was not yet available when the DAGS’95 proceedings were built.
2. Digitize material:
Transparencies were scanned and screen-shots from the speakers software-based presentations were converted to images.

3. Basic editing and indexing:
The speakers were videotaped to capture the audio (the speakers voice) and to provide synchronization between the speaker’s voice and the slides. Slides were ordered based on the video of the talk. The audio track of the video was digitized using commercial video editing software. The samples were manually cleaned from noise and superfluous 'uhm’s' and ‘ahh’s using the same applications. Unused slides were omitted while some others were concatenated into one image.

4. Semantic editing and indexing:
The sound track for each slide was cut into 30 to 50 second sound clips. The audio edit guidelines were (sorted by decreasing priority) (1) to synchronize the slides and audio-clips, (2) to lets speakers complete a sentence, and (3) to have sound clips of approximately 300 KBytes. Sound samples that were shorter than 20 seconds were either added to the previous or next sample.

5. Create HTML and auxiliary files:
Once the slides were available as sorted GIF files, we used HyperCard stack (named “AWCF”) to automatically generate the HTML, GIF control panel description and imagemap files based on the listing of the slide titles per talk. This step is described in detail in the next section.

6. Create images for control panels:
In the next step, the GIF control panel image files had to be generated based on the description file generated in the previous step. We used DeBabelizer™, a commercial Macintosh graphics program that allows to create and edit collections of graphics files in batch mode.

7. Integration and testing:
In the last step we linked together all the files, placed them on the server and tested the validity of the links.
5. A Tool for Automating the Web Authoring Process

Timeliness is a critical feature for conference proceedings, as conference attendees are used to getting printed proceedings at the beginning of the conference. This means, that talks to be disseminated should not appear years after the conference, but be published weeks to at most months after the conference. Turnaround-time for the CD-ROM-based DAGS’92 and DAGS’93 multimedia proceedings was at least one-year. For DAGS’95 it was possible to speed up the development process to three months past the conference because of three main factors: (1) experience with what material to collect and parallel processing of these, (2) placing the burden of hypertext (HTML) authoring on the author rather than on the production team, and (3) development of new production tools.

The most important tool we implemented was “A Web Conference Factory” (AWCF), a HyperCard stack that automatically creates all of the HTML, imagemap, and dummy control panel files for the digital talks. AWCF supports the following blueprint: Our final screen design required that each slide would be mounted on a separate page, i.e., a different HTML file. The HTML file displays the actual slide title in the list of contents in italics, and also brings up appropriate control panel and slide images. The control panel (an image in interlaced GIF format) has to be produced for every slide because the correct number of sound buttons and the title of the slide have to be displayed. Besides HTML files, a WWW page relying on an imagemap also requires a “.map” file to correctly react to clicks within the image. A typical one-hour talk in which 30 slides are shown requires the following:

- Around 90 sound clips.
- 30 interlaced GIF images of slides (our screen design allowed for a maximal image width of 287 pixels with most 256 different colors).
- 30 control panel GIF images.
- 30 HTML files.
- 30 map files (which contain individual sets of URLs for each slide).

Out of a total 210 files, 30 HTML, 30 map and 30 dummy control panel files are generated by AWCF. This means that AWCF relieves electronic proceedings editors from having to manually edit HTML text and from having to use an imagemap tool to manually assign links to clickable areas of an image.

6. Conclusion

Multimedia Conference Proceedings on the web is a valuable experimentation platform to study ways of reproducing the experience of a live conference or classroom on the web. While it is still not possible to mass-produce such publications and very expensive to produce custom-made ones, the clear advantages compared to traditional publishing warrant further research. For web-based multimedia publishing to really take off, the authoring and editing process needs to be greatly improved and in particular new tools need to be developed that allow a novice in multimedia to author or edit multimedia type of contributions. For example, the web version of our last generation of electronic publishing (DAGS’95) had a significantly reduced turnaround time with a new tool called AWCF application that facilitates the integration of different multimedia objects on web pages and automates basic hypertext and multimedia authoring.

Multimedia data access on the web assumes that the user works in an integrated hypermedia environment where the digital conference (video) talks are tightly coupled with the hypertext (text) papers. Improvements needed include ways to automate repetitive tasks and ways to enhance and automate the initial content gathering process (collection of raw material in a format suitable for further processing).

References


Abstract: This paper will draw on several projects which I direct from Exeter in the UK with the aim of bringing teachers onto the Superhighways. We believe that teachers can benefit from the resources and collaboration available over the highways. More important, however, is the involvement of teachers in the development of the Superhighways, because teachers are the key to the proper development of the global Information Superhighways. The overarching aim of these projects is to develop and research the role of multimedia telematics (telecommunications and information technology) as an infrastructure for the future learning society. The overview starts with a description of the creation of multimedia materials and flexible learning for teacher education and moves through point to point and networked telecommunications projects in the UK, ending with international projects linking countries in Europe and collaboration with North America.

Introduction

There have been calls for the development of global Information Superhighways around the world. For example that by Al Gore in the USA and the Bangerman Report in Europe. The Superhighways are seen as a major part of the infrastructure required for the emergence of a culture of life long learning. 1996 is the European Year of Lifelong Learning. This is essential for both economic and social reasons including, of course, the intolerable social exclusion and uncertainty experienced by the unemployed.

The policy makers have therefore become more involved in raising awareness and an expectation of opportunities to learn at any time in any place using the global Information Superhighways. Companies and other commercial organisation have also become aware of the potential of new and major market opportunities. Educational organisations are also waking up to the need for new practices and partnerships. This paper considers these opportunities and challenges from the view of teacher educators. However, before I describe recent work, it is necessary to provide a brief overview of previous work in this field.

Background

The use of communications and information technology in education is not new and we can learn a lot from the projects which have been developed over the last fifteen years around the world. Veen et al [1994] review a range of communication and information technology projects within and across European countries. The majority describe the collaborative use of electronic mail between schools nationally and internationally. A few provide case studies in teacher education, including some of our early work in Exeter. Veen et al attempt to draw out the lessons from these projects to provide a basis for teachers new to the use of electronic communications in education and to policy makers.

There have been significant projects in the far East and Australasia. The USA too has encouraged widespread use of electronic communications over the years. Seminal work by Glen Bull in the University of Virginia resulted in much of that state’s educational system being linked to the Internet several years ago. Similarly there have been major projects in states such as Florida and Texas. Ruopp et al [1993] describe an in depth and long term project called LabnNet which attempts to develop a community of practice among teachers for supporting each other’s professional across the USA.

Companies such as A T & T have become involved in the development of services under the guidance of experts such as Margaret Riel. Attempts have also been made to quantify the benefits of such electronic information and communication services. For example, Riel [1994] provides evidence related to development of the skills that employers wish to see in their new recruits.
Continuing developments

New technologies have continued to develop apace providing richer sources of information in images and sound in addition to text based Email, telephone conversations and broadcast TV. New opportunities also arise through new partnerships. Central funding of new technologies to increase the quality of higher education has provided the impetuous to form consortia across disciplines and institutions. Similarly the need to understand the education market in depth has prompted commercial organisations to collaborate with teachers and other educators. There is also an increasing demand for education and training from those beyond the traditional boundaries of education, hopefully a precursor of a proactive movement for lifelong learning. All of these factors underlie our work in developing telematics in the University of Exeter School of Education. The remainder of this paper describes projects and issues within these themes leading hopefully towards global Information Superhighways for learning.

Multimedia

Our project ‘Images for teaching education’ is creating multimedia materials for teacher education and ensuring their use within teacher education across the UK. It is within the UK Teaching and Learning Programme funded by the four agencies which fund higher education in the UK. The four sets of resources which are complimented with a framework for flexible learning are:

1. Critical encounters in the secondary classroom (bar coded Interactive Videodisk)
2. Multimedia in the learning environment (bar coded Interactive Videodisk)
3. Design and Technology PhotoCD
4. Chalk lands PhotoCD with sound (Portfolio)

This final year of our three year project involves trial and evaluation of the materials in several Universities across the UK with final adjustments to the complimentary documentation. In Northern Ireland in February I evaluated the use of ‘Critical Encounters’ in Queen’s University Belfast. The lively discussions provided evidence of the development of student teachers’ critical facilities in sessions led by staff and in follow-up sessions where students used the material in groups of 5 or 6. The students were also enthusiastic in their evaluation of the materials and suggested other clients such as practising teachers, youth workers and for use when interviewing prospective student teachers.

The project has involved an inter-disciplinary team across four universities. It has forced us to consider the ways in which we use sound and images with staff and students. One result of this development and research is increased depth in our perceptions of how and why multimedia are important in the process of teaching. We have already incorporated several of these insights into our materials, because we aim for each resource to be an exemplar through which others are encouraged to adopt, adapt and develop their practice. This applies most closely to teacher education, but includes other disciplines too.

Our development work has also helped us to understand the importance of an adequate quality of both sound and images. It is not simply an issue of standards and speed. The main focus must be: Does it communicate what needs to be communicated? Take for example one video-clip from ‘Critical encounters in the secondary classroom’: ‘Muttered remark’. By its very nature the sound should not be too loud or clear, but if quality or image falls much, then nobody can hear the muttered remark nor see the implicit challenge in the student’s behaviour. When these aspects are dropped then the clip loses its power to stimulate the discussion necessary to promote learning. The same issue occurs with still images where the student is being helped to develop a highly sophisticated perception. For example, in the ‘Chalklands’ PhotoCD one aerial image of an expanse of grassland needs to show enough colour and detail to encourage the identification of the variety of chalk land plants.

Transferring the format of delivery from slide to PhotoCD raises a range of issues: technical, media, and flexible learning. We have also had to address more commercial issues such as copyright and working with publishers to address niche markets which are unused to paying directly for learning resources. Such issues will be raised time and again as we move across the many implementations of the Information Superhighways. The medium is not the message, but it does influence its delivery!
Multimedia communications over ISDN

Over the past three years we have been developing a range of services for schools and higher education in a project entitled ‘Multimedia communication services’ [see Davis, 1995, for example]. We used DeskTop Conferencing with an audio telephone line [classified as enhanced audio graphics in Mason, 1994]. Two computers connected over ISDN telephone lines permit individuals or small groups in different locations to share software and other activities. These projects started with the aim of helping student teachers to test teaching ideas remotely from the University. What proved most successful, however, was a personalised and intensive form of on-site professional development for school staff complimented with remote student teacher supervision from the University. This is now under further development with the addition of a video window, which therefore provides enhanced video desk top Conferencing.

Reflective practice

Although we have produced and replicated case studies of good practice with telecommunications, we have not yet put them to rigorous research. In particular, the ISDN links to supervise students in schools or other work placements require research. We want to explore whether they enhance the development of the reflective practice that we aim to foster in our student teachers. Our early case studies suggest that this is the case. Pilot research is now underway to test this hypothesis through the collection of qualitative data from staff and students as part of a collaborative European project called REFLECT. Colleagues in Utrecht, Trondheim and Barcelona are asking similar research questions of their parallel projects. Our workshop at Easter 1996 will assess the potential for comparing research across European countries and Telematic networks.

UK Superhighways Project

Our work with telematics and teacher education prompted one of the leading IT companies in the UK to employ us within the major Superhighways for Education pilot in the UK: the Bristol On-Line Education Network (BEON). It is joint project of International Computers Limited (ICL) and British Telecom PLC. One of my tasks is to educate the companies about the education market: no easy task as this involves confronting major cultural differences. I can illustrate this with a remark within a strategic meeting where one company requested that the schools adopt an approach of ‘an aggressive client’. Aggression something which schools try to minimise and they would find it impossible to a their precise needs of a service. Without such a specification it is impossible to demand ones rights. I am also attempting to change the companies categorisation of issues from ‘hard/soft’ into ‘cold/warm’. This is because the ‘soft’ issues involving teachers and children are actually harder than the ‘hard’ technical issues. In constrast, recalssifying peole related issues as ‘warm’ is more appropriate, because they are organic and will not respond well to either lack of attention nor to too much pressure.

The aim of BEON is to develop and evaluate the potential of a managed ‘Superhighways’ service for schools in the UK. BT and ICL see BEON as a trial across 11 schools which might become a scaleable model of the Information Superhighway. They are keen to understand a new range of potential customers. Several forms of telecommunications are being used to provide over a thousand students and staff in the schools with a wide range of resources, facilities and professional development. Integrated Learning Systems, CD ROMs, the Internet and other resources will be managed centrally for the schools. My team in the University of Exeter is providing intensive support for teachers to assist them to integrate these new facilities into their schools. Curriculum enrichment and professional development include sessions through enhanced video desk top Conferencing over ISDN. The team will be complimented with experts from around the UK as appropriate to their needs. My observation of such sessions provided to a primary teacher in her own classroom with her class in the background shows a clear model of life long learning on the job!

The Internet

Through another project funded by the UK Joint Information Systems Committee (JISC) called ‘Multimedia teaching through SuperJANET and ISDN’, we are attempting to increase our range of instructional strategies to
encompass larger groups and for professional development in higher education. The project is sharing expertise between universities and complimented it with professional development for the staff involved.

Our plan to transfer the approach of an intensive tutorial from ISDN to Internet was thwarted by the architecture of the Internet. The links between participants were simply too unstable to permit real time sharing of screens or resources [Wright, 1995]. We did not have the dedicated bandwidth that ISDN had provided (64 K), even though the potential bandwidth (10 MB) was much larger. Other approaches have therefore been developed to permitted remote teaching using an ordinary voice telephone line to compliment multimedia on the Internet.

I will now describe one of our approaches in detail. It permits an ‘expert’ to ‘teach’ a group of students on another site. The experts we are working with include teacher educators, scientists and practising artists. The expert is assisted to create a set of resources, usually including multimedia in the form of still pictures, text and occasionally sound. For example, a visual questionnaire on environmental issues. The pictures are embedded in an ‘html document’, usually a form, with space for student input. The expert is linked to the student for an introductory stimulus session with an ordinary telephone connection and both ends use their WWW server to view the same stimulus material. Following this session the students work through the material and their input is e-mailed to the expert in the normal way. Alternatively students may place their material on WWW themselves. This student work is then reviewed and an overview placed onto the WWW adjacent to the stimulus material. The teaching is rounded off with a final connection by phone to provide additional information and review. This mode of learning is valuable to several groups of people: the students addressed over the phone, other students who have access to the Internet and to researchers in the field if they are interested in the opinions of the students.

Collaborative development with central and eastern Europe

The European Commission has provided funding for projects to assist countries in transition. Communication and information technologies have been seen to be an important part of this work. One such Copernicus project involves Exeter in assisting our colleagues in Bulgaria, Lithuania and the Ukraine to research the development of flexible and distance learning courses in ‘English’ and ‘Communications and IT’. It is co-ordinated by Ivan Stanchev, an information scientist in the University of Twente in The Netherlands. I lead the telematics strand and my colleague Paul Harvey in our English Language Centre leads the strand for courses in English. Not surprisingly, the project is proving to be an enormous challenge across cultures and languages. Until I visited Lithuania in November 1995 I had little idea of the pressures on staff and the lack of an infrastructure for flexible learning. Few English speaking staff remain in higher education due to the demand for them in business and students have major difficulties in accessing resources for flexible learning outside the universities, even warm space in which to study. However, we are making progress in designing courses collaboratively and Exeter will be using the Internet as one means of delivery of a part time course in ‘course design’ for the English tutors in our partner universities.

Professional development over the Internet

The Copernicus project is not my first venture into professional development over the Internet. I have been working to encourage the use of electronic communications to enhance teaching and learning for over ten years. Early work created a national electronic network for pre-vocational education and training across the UK [Davis, 1988], which has now been superseded. I believe that there is enormous potential in the networking of people and information, especially where access is open and friendly. The Society of Information Technology and Teacher Education in the USA has recently created a WWW site called InSITE to encourage further development of the teacher education community which collaborates in their research and practice [Robin et al, 1995]. I am curator of the International section providing information and links outside the USA. The address is: http://teach.virginia.edu/insite

This year the European Commission have funded three projects to develop and research information and communication technologies for teachers. I co-ordinate the one called ‘Telematics for Teacher Training’ (T3) which started in January 1996. Over the next three years we will use Telematics within courses for teachers across seven European countries. One of the supporting strands is the creation of a Euro-centric Web site which I named ‘T3Centrum’. Here our consortium aims to place resources, project information and discussion groups so that it becomes a valuable place for teachers, teacher educators and library staff to ‘meet’ and support each other.
The T3Centrum can be located via our Telematics pages in Exeter at: http://www.ex.ac.uk/telematics. It will be interesting to see whether we can build a variety of networks with teachers to enhance their professional development and practice with telecommunications, such as that developed through LabNet [Ruopp, 1993].

Conclusion

The research and development described in this paper provides an overview of the variety of ways in which future global Information Superhighways will enhance learning. I hope that it also provides a view of the ways in which research is changing due to collaboration and partnership supported by Telematics. On site in Exeter we have an important range of personnel and facilities. Overlapping teams provide a supportive ethos for each other’s work within the normal business of a large department of teacher education with the highest possible rating for research. The School of Education and the university itself provide an important reservoir of support and we aim to return this compliment by providing additional facilities and opportunities for teaching, staff development and research. The links that each project team has with a wider team in other organisations in the UK and abroad are also important. These development teams include a wide range of business, technical, scientific, and educational expertise. In common with most interdisciplinary projects we benefit enormously from the variety of view points. I feel that such collaboration will be essential to the proper development of the Information Superhighway: educators educating those with a commercial focus and our commercial partners helping educators to come to an understanding of the constraints and opportunities of technologies and commercial practices. Similarly, we benefit from the development of an understanding of learning in other countries and locations.

This paper has aimed to provide an overview of a range of projects to illustrate the importance of educators, especially teachers, becoming involved in the development of the Information Superhighway. I hope that it has also illustrated that there are a wide range of complex issues. Such research and development will be an important aspect of professional development for educators. We believe that there is equally important professional development for the commercial partners and those in other disciplines such as technology. Our current Information Society, as it transforms into the proposed Learning Society, needs teachers to develop the infrastructure in collaboration with the commercial service providers. The rich mixture of knowledge, experience and cultural variety which is evident across disciplines in academia and commerce is essential. We also need to communicate the importance of this collaborative mix and trust that it will have the hybrid vigour necessary to tackle the complex issues that will be encountered.

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Multiple Perspectives on Using Multimedia To Provide a Common "Text" for the Study of Innovative Teaching

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Usually when educators think of teachers in conjunction with multimedia, the problem in focus is teaching teachers TO USE multimedia. This panel will focus instead on teaching teachers USING multimedia.

One of the problems that arises in teaching teachers to work in ways that are new and unfamiliar is finding an example of what the new practices could look like. Another problem is that teacher-learners and teacher educators are not in the habit of examining and understanding new practices. Often innovations are touted in situations where neither the teacher educator nor the teacher has much experience with doing the kind of teaching that is being promoted. One solution to these problems is to put learners in apprenticeship situations, but that solution is inadequate for two important reasons: 1). there are not enough classroom where innovation is happening to go around among all those who want to learn and 2). if learners all have experiences of DIFFERENT classrooms, there is no common ground with which they can build a shared understanding of the new practices.

Each of the panelists has taken a different approach to using multimedia to provide teachers who want to learn about innovation with a common "text" to study. Each has amassed a rich corpus of information about innovative teaching in video, audio, graphic, and print forms. Each has a unique experience with using technology to catalog, access, and annotate this information. And each has experienced the joys and problems of a technology-rich approach to educating teachers.

Some of the issues that should provide for a lively discussion among the panelists and with the audience include: how to use computing technology to support the investigation of teaching as opposed to simply showing "good models", how to respect the teacher and children in the materials and at the same time talk honestly about the strengths and weaknesses of the teaching and learning; how to get beyond the good-teaching-bad-teaching generalities and use technology to really examine what it takes to do a new kind of teaching and learning; how to use technology to help users choose from among a myriad of examples to provoke good discussion; and how to assess what teachers take with them from their experience with a multimedia "case" into their own classrooms.
Teachers’ conversations about their teaching can be rich and productive. Pedagogical discussions must have an "it", or a focus. But often teachers do not spend time in colleagues’ classrooms and lack shared images of teaching.

The Talking Mathematics project used three vehicles to help establish shared images as the focus of pedagogy discussions:
1. Doing mathematics together.
2. Common readings about teaching and learning. 3. Videotapes of participants' classrooms. We have come to believe that a productive context for reflection involves these elements:
   * shared goals
   * shared norms about reflecting on practice
   * comfort with members' roles and value in the community
   * acknowledgment of the complexity of teaching practice.

In a teacher seminar we can see only pieces of classroom sessions. Making judgments does not enrich discussions about pedagogy. In a genuinely reflective culture, teachers learn to see themselves in new ways. When teachers cite examples and consider their meaning thoughtful conversation often emerges.

Here is one excerpt:
Sandra: When there's an idea, a few minutes later another child will come up with another idea, and make a connection. It's like piggyback but delayed. ... At that point, I know that child was listening. Katherine: One way I can tell that kids are listening, in small groups or large groups, when they say, my idea is different from Jaime's idea or is similar to Rose's. Using other people's name to refer to a mathematical idea is listening. ... They compare [their ideas with] it... It's a sign of respect.

Carefully selected videotapes provide a vision of practice that can be viewed and re-viewed. Considering a shared image allows teachers' discourse to be focused. In this presentation, we will all focus on one teacher whose use of videotape as a reflective tool allowed her to change her teaching practice in ways she found extremely satisfying.
Video Analysis in an On-Line Professional Community

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The purpose of the Mathematics Learning Forums Project is to create an on-line learning community for teachers and researchers in collaboration with the Bank Street College Mathematics Leadership faculty. The Forums project is funded by the Annenberg CPB Math and Science Project. It offers k-8 teachers intensive eight-week seminars on content and teaching issues in mathematics. The Forums are designed to help introduce new mathematics teaching practices into classrooms in accordance with current nationwide reform efforts.

The emphasis in the Forums is on using telecommunications to support a multifaceted learning process, which uses discussion among peers discussion with a faculty facilitator/moderator, in class experimentation, readings, and videos to bring teachers in contact with innovative techniques for K-8 mathematics. Each Mathematics Learning Forum is offered over a telecommunications network, making it possible for teachers to communicate with colleagues throughout the country.

In the course of working on this project, we are learning a great deal about how to design effective virtual learning communities for teachers. We have found that building a "safe" environment, creating rich and descriptive representations of practice, designing content that is flexible, and constructing a sound technical environment are all necessary components of this process.

We have been especially interested in using multimedia technologies to find ways to assess the effects of teachers' participation in the forums on their understanding of teaching and learning. What are changes in their thinking dependent on? How can we represent this dependence? What can we look at to gauge the kinds of changes that are occurring? How can we organize this information? How can we create multimedia materials that represent what happens in the forums?
Because Japanese students have scored so high in international comparisons of mathematics achievement, there is a great deal of interest in how mathematics is taught in Japanese classrooms. We have collected hundreds of hours of video in Japanese elementary school mathematics classrooms. In an ongoing project we are investigating the usefulness of these tapes for the improvement of mathematics instruction in the United States.

We have used the tapes in the context of a teacher development group that met weekly for two years in an elementary school. During the first year of our project we asked the group to watch video tapes of Japanese teachers teaching mathematics to their elementary school students and to try to understand the approach to teaching employed in these tapes. During the second year we asked the same group of teachers to teach lessons like the ones they had seen on the tapes.

In this presentation I will describe what we have learned, and what the teachers have learned, from this project. To summarize, teachers found the discussion of Japanese tapes to be highly useful and relevant for their own development. What they learned, primarily, was a language for talking about instruction, both Japanese and their own. For the first time, these teachers developed a theory linked to a set of examples that they could use for the analysis of classroom instruction. They applied this new knowledge to the analysis of their own instruction, and to the task of reflecting on changes in their own teaching practices. We believe--and I will explain why in this presentation--that exposure to Japanese examples was crucial in this process, and that these results would have been difficult to achieve by viewing only the more familiar tapes of American teachers.
Since 1989, the M.A.T.H. (Mathematics and Teaching through Hypermedia) Project has been experimenting with new approaches to the curriculum, pedagogy, and contexts of teacher education. The project's aim has been to design and analyze ways of engaging undergraduate prospective teachers and teacher educators in studying teaching for understanding through the investigation of multimedia materials that document teaching and learning in two elementary school mathematics classrooms. Supported by grants from the National Science Foundation, this research project has been focusing on innovative approaches to the pedagogy of teacher education and the learning of prospective teachers.

Drawing on hypermedia technology as a resource for new approaches to the study of teaching, we have been developing and experimenting with tools for navigating through video, graphic, and textual material that was collected across a full year of mathematics lessons in two elementary classrooms (one third grade and one fifth grade). The data we collected and organized include videotapes of most days of math lessons, copies of children's work, quizzes, tests, and report cards, and the teacher's journal. We have developed a hypermedia learning environment in which teachers and prospective teachers can have access to these data, and can use the material as the territory for studying teaching and learning. The tools we have built enable users to select and copy information of all kinds, including video segments, and to store it in a personal or group electronic "notebook" where they annotate and illustrate the information.

Our aim in this work has been to investigate what it might take to develop a different context for teachers' learning, one that is connected to but also distinct from either course or field experiences. We argue that learning a field entails not just learning particular skills and strategies or ideas and theories, but also learning the field's characteristic ways of knowing and of constructing new knowledge. This means learning to generate conjectures and seek evidence, to formulate questions and make arguments, to play out ideas and make revisions. We think this means engaging prospective teachers as active constructors of knowledge about teaching and learning. And it means rethinking our roles as teacher educators, making a shift from functioning as providers of knowledge for teaching to serving as facilitators of inquiry into teaching.