"Intelligent Embedded Microsystems" Distance Learning in Microsystem Engineering and Applied Computer Science

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ABSTRACT

"Intelligent Embedded Microsystems" (IEMS) is a novel distance learning Master of Science degree program at the University of Freiburg, Germany. Postgraduate education in several subjects like microsystems engineering and microelectronics, as well as applied computer science is merged in a way that meets most of the students' and industries' requirements for a non-consecutive in-service study program. Thereby a broad range of target groups is addressed leading all of them to one common master's degree which also fulfils the requirements of the Bologna process. This paper describes the implementation of this novel program which has been just accredited with a quality seal by an independent accreditation, certification and quality assurance institute.

1. INTRODUCTION

Recent changes in curricula, caused by the Bologna process [1], bring up the need to revise the educational structures at universities in Europe. Until 2010 all study programs have to be adapted to the bachelor/master system to fulfil the requirements of the Bologna process. In addition, in Germany the introduction of tuition fees increases the pressure on and competition between universities. With the upcoming distance learning methods, this competition reaches a higher level entering the world wide market.

The equal ranking of all the different bachelor's degrees (of universities, German Fachhochschulen (FH) as well as Berufsakademien (BA) [2]) opens the master programs of the universities to a completely new audience. All students with a bachelor's degree can now continue their studies at the university to get a master's degree.

Even with the so-called equivalence of the bachelor's degrees mentioned above students coming from these different institutions still have different levels of qualification. Therefore a curriculum addressing all of these students has to consider this issue of differing knowledge background with split course programs to fulfil the requisites of the master program. In Germany, especially in Baden-Württemberg, students have to fulfil a minimum of 300 ECTS-credit points [3] in total to get a master's degree. A student with a bachelor's degree of a university usually finishes his studies with 180 ECTS credit points. Other students with bachelor's degrees might get 210 ECTS credit points during a seven semester study program at a German Fachhochschule. The sums of these different achievements and the ECTS credit points received during the master program have to result in 300 ECTS credit points in total. This means that students with different backgrounds need different study programs. We address this issue with an extensible and split curriculum with different durations, where the different target groups take differing courses which lead them to their master's degree.

Another problem that has to be addressed within the new program is the requested "industry-oriented education". This refers to the seamless incorporation of industry-related issues into the current university curricula, which are expected to complement the institution's original research and teaching tasks. The ideal case would be to have case studies describing companies' problems; starting a lecture from an example makes it easier for students to learn the contents. However for the more theoretical courses such examples are often hard to find.

This paper presents how the new program *Master Online Intelligent Embedded Microsystems (IEMS)* addresses all these challenges with an innovative curriculum using distance learning methods. A blended learning approach and cooperation with the industry offer students the possibility of in-service training. Section 2 describes the new distance learning curriculum developed at the University of Freiburg. This curriculum is open to students with a first degree of different kinds of institutions and hence with differing knowledge background. It is an in-service training study program (i.e. students stay in employment while studying) and leads to a Master of Science within three to seven semesters. In section 3 the blended learning approach used in this curriculum is described in detail.

2. DEVELOPMENT OF A NEW DISTANCE LEARNING CURRICULUM

The Faculty of Applied Sciences of the University of Freiburg comprises two main departments: the Department of Microsystems Engineering and the Department of Computer Science. Both offer a wide range of topics and expert knowledge in the field of embedded microsystems. The Department of Computer Science provides the more theoretical background for efficiency, correctness, development and analyses of algorithms. The Department of Microsystems Engineering places its emphasis on hardware-related issues involving materials, chip design, connectivity etc. Combined, the developed curriculum offers two areas of expertise – algorithms and engineering. The new study program *Master Online IEMS* takes advantage of the expertise of both departments to convey the skills needed to design and develop modern high-tech embedded systems.

But most important is the curriculum's flexibility in order to admit students with a first degree from different kinds of institutions (as mentioned in Section 1). Therefore different model study programs for those three target groups were created. All three model study programs have a different duration (between three and seven semesters) and require the students to study a different number of modules. To make sure all interested students can study the same advanced modules during their main studies, they should all have a comparable level of qualification when starting this part of the master program. Therefore the so-called methods- and basic mod-

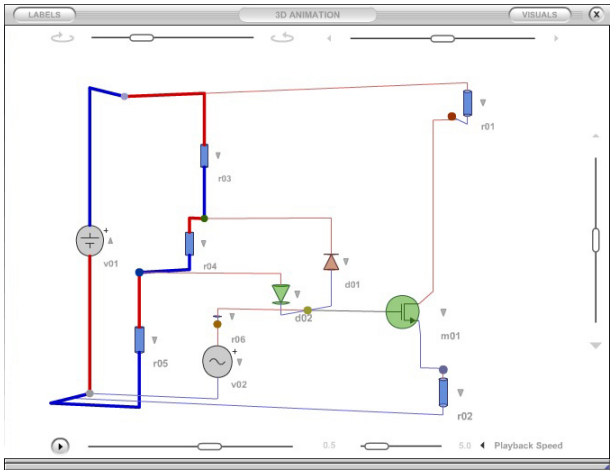


Figure 1. Screenshot of *Spicy VOLTsim*.

ules were introduced which depending on the first degree of the students have to be taken before the advanced modules.

To achieve this not only the combined curriculum had to be developed but also the concepts for the modules (lectures) and their presentation. Long-distance practical exercises and lab-courses which are quite important to depict the contents of teaching and explain them intuitively had to be designed, too. There also exists a team project as well as a project management module and finally the master thesis.

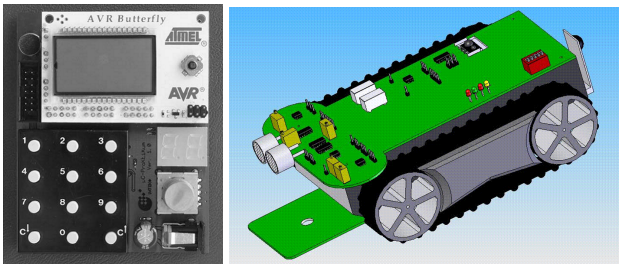
3. Blended Learning: Our Approach

Another point that had to be kept in mind while designing the curriculum was that most students would prefer to get their master's degree as in-service training. This way they would be able to stay on their job while doing their studies. Hence, we decided to develop the whole study program as a non-consecutive in-service training which is taught in a distance learning scenario.

For this purpose blended learning in both theoretical and practical courses is employed. The theoretical background is taught to the students using so called *eLectures* [4] which are produced with the *Lecturnity* recording system [5]. This system makes it very easy to record presentations (e.g. Microsoft PowerPoint), the speaker's voice, and annotations on the slides. The students can watch the resulting multimedia documents which are distributed via a learning management system and are accompanied by exercises and mentoring (via forums, chat, e-mail, phone or video conference) by specially trained tutors.

Those lectures dealing with electronic/microelectronic devices and their applications make an extensive use of circuit simulation software – namely *PSpice* – to stress out the practical character of the discussed circuits. This should also incite the students to "play" with electronic devices and circuits and gain their own experience on these topics. Also very valuable is a computer aided visualization-methodology for the three-dimensional animation of analog circuits: *Spicy VOLTsim* [6, 7] which was developed as an online application at the Chair of Microelectronics at the Department of Microsystems Engineering. Basically, this tool operates with Spice simulations in the background but presents the results in a very intuitive and demonstrative graphic fashion as can be seen in Fig. 1.

Also some of the practical courses have been adapted especially for this program: there are portable design kits consisting of the required tools for the given tasks, such as microprocessor sets as shown in Fig. 2(a), measurement devices, etc. These kits are lent to the students for the duration of the course and they can experiment and solve the given tasks at home in their own time. Figure 2(b) shows a measurement robot with several sensors, wireless communication, etc. which was developed for exactly this purpose at the Laboratory for Electrical Instrumentation (at the Department of Microsystems Engineering).



(a) **Microprocessor set.** (b) **Measurement robot.**

Figure 2. Portable design kits for the students.

4. Conclusion

This article shows how it is possible to fit a course program for different target groups into one curriculum. The blended learning method is the ideal combination of easy, inexpensive production of recorded lectures and a high-quality tutoring to fulfil the in-service training needs even in the field of electronics/microelectronics and microsystem education.

Since the Faculty of Applied Sciences of the University of Freiburg has a lot of experience in this field, this method is expected to be successful in the near future (not only for *Master Online IEMS* but also for other study programs). Our approach for this kind of curriculum has gained the support of the German Ministry of Education which has approved the funding of the first three years of the study program of *Master Online IEMS*.

This novel program has been just accredited with a quality seal by an independent accreditation, certification and quality assurance institute.

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