Accreditation practice for degree programs in Computer Science: Experience gained at a classical research university in Germany.

Thomas Ottmann, Christoph Hermann[1], Christoph Heumann[2]

[1]Georges-Köhler-Allee Geb. 51, 79110 Freiburg, Germany,
ottmann@informatik.uni-freiburg.de; hermann@informatik.uni-freiburg.de

[2] ASIIN e.V., Robert-Stolz-Straße 5, 40470 Düsseldorf, Deutschland
heumann@asiin.de

In this paper we outline how large German research universities handle the Bologna reform. We in particular describe how they fulfill the requirement to accredit their new undergraduate and graduate programs. A description of the general framework is complemented by specific examples and experiences gained in the accreditation process of the computer science programs at the University of Freiburg. We in particular illustrate the positive effects of peer review in the accreditation process for the design and implementation of the new degree programs and disclose hurdles solved for the accreditation. It turns out that the external program accreditation of all degree programs is complex and expensive. Therefore, large traditional universities go for the so called systems accreditation. The aim is to make external program accreditation superfluous once an efficient internal quality management system is implemented and operational. We outline some advantages and disadvantages of system accreditation (*Systemakkreditierung*) versus program accreditation and conclude with lessons learned during our accreditation experience.

Keywords

Program versus System Accreditation, Quality Control, Changing Computer Science Programs, Bologna Reform, German Research Universities

1. General framework for accreditation

In the German federal system, the responsibility for higher education mainly lies with the 16 federal states (*Bundesländer*) and their respective ministries for higher education. Parallel to the introduction of the two-cycle structure with Bachelor's and Master's programs by Germany's universities as a result of the Bologna process, quality control has been transferred from the state ministries of higher education to accrediting bodies founded by the higher education institutions (HEIs) themselves, sometimes in co-operation with other stakeholders in higher education. This change goes along with a transfer of responsibility from the state to the HEIs, leading to greater autonomy on the part of universities, but also to new administrative responsibilities and to requirements regarding the documentation of the quality of their processes, also with regard to the development and implementation of the new Bachelor's and Master's degree programs. In the past, the state ministries of higher education had a much more direct influence on the state-funded universities and their degree programs. Nowadays, most state higher education laws just contain the requirement that degree programs must be accredited.

The accreditation system in Germany is regulated by the Accreditation Council (*Akkreditierungsrat*) which was established by the 16 federal states as a foundation under public law. The Accreditation Council sets the standards and guidelines for the accreditation agencies and awards the right to accredit degree programs. Currently, six accreditation agencies have been authorized by the Accreditation Council to award its Seal to accredited Bachelor's and Master's degree programs: ACQUIN, AHPGS, AQAS, ASIIN, FIBAA, and ZEVA[1].

Three of these cover the entire breadth of academic education, the other half focuses its activities on certain subject areas. The accreditation agency ASIIN e. V., for instance, is specialized in the accreditation of degree programs in engineering and informatics/computer science, as well as mathematics, biology, physics, chemistry, geosciences and pharmacy. Most computer science programs offered at German universities and universities of applied sciences (*Fachhochschulen*, UAS) are accredited by ASIIN. ASIIN e. V. is organized as a non-profit association carried not only by networks of HEIs, but also by federations and trade associations (including the federal association of state engineering chambers), scientific societies and umbrella organizations from industry and trade unions – all of which are active in the fields of technology and natural sciences. It is supported by the national bodies representing the faculties of engineering and natural sciences at German universities and universities of applied sciences.

The Bologna reform has not only changed the administrative framework for quality control but also shifted the focus from learning inputs to educational objectives and learning outcomes. The objectives of a degree program should reflect the needs of the different stakeholders in higher education: academia, industry, state governments, and students. The accreditation process must ensure that degree programs seeking accreditation meet their objectives. The assessment method is the same for all German accreditation agencies: First, any degree program must specify its objectives; this requirement is then further elaborated by a number of key questions to be answered (what subject-specific and subject-independent competences/qualifications are being imparted, how is the employability of graduates achieved, what are typical occupational fields for graduates, what is the specific profile of the degree program, and further similar questions). Second, the concept of the degree program and its implementation must assure that the objectives are met and that the HEI has the necessary means to carry out the program. Some accreditation agencies, like ASIIN e. V., complement the general requirements and procedural principles by subject-specific criteria. These are conceived as parameters for orientation and comparison against this background, allowing for reasonable deviations and serving as an orientation for application and auditing of degree programs in the accreditation procedure. ASIIN e. V. has 13 technical committees (TC) for the various disciplines represented within ASIIN. They formulate learning outcomes and objectives, develop the subject-specific criteria and guidelines, nominate audit teams for accreditation procedures, and review and comment reports of audits to the Accreditation Commission. This is not done in isolation but in discussion with the scientific organizations, future employers of graduates, and students.

Beyond the fitness of purpose of the Bachelor's or Master's degree program and the correspondence of its objectives to the needs of the stakeholders in the higher education process, the Standing Conference of the Ministers of Education and Cultural Affairs (*Kultusministerkonferenz*, KMK) of the 16 federal states has set common structural guidelines for Bachelor's and Master's programs, compliance with which is also checked in the accreditation process. These guidelines specify modularization, the award of credit points, and the duration of degree programs; they regulate entry requirements and transition,

[1] http://www.akkreditierungsrat.de/index.php?id=5

distinguish between different profiles and types of Master's programs, and clarify the equivalence of the new degrees with the traditional one-cycle diploma degrees.

In what follows we briefly characterize the different versions of how the learning outcomes of undergraduate and graduate programs in informatics/computer science are specified in the subject-specific criteria of the TC 04 of ASIIN, which is the technical committee responsible for informatics/computer science. The specification is by far less detailed than the one developed by the ACM/IEEE joint task force contained in the Computing Curricula 2001 Report [4]. The specification does not distinguish between different computing related fields but tries to roughly characterize the body of knowledge and competences to be expected from every graduate of a computer science program in about 10 pages. The subject specific competences comprise formal, algorithmic, and mathematical competences, analysis, design and implementation abilities, as well as technological and application-oriented competences. No detailed curricular recommendations and no sample programs or course descriptions are given. Thus, the requirements are much more generic than the ACM/IEEE recommendations or the guidelines compiled by the German Computer Science Society GI [5]. A typical example is the specification of the formal, algorithmic, and mathematical competences to be expected from every computer science graduate:

> *Graduates of any informatics program are able to analyze, structure, and describe real world problems by formal means. They can transfer formal requirements into correctly implemented and efficient solutions using currently available hardware- and software systems. They are able to identify the algorithmic core of a problem and have a good command of the respective algorithms, data structures, and patterns for solving problems. They are able to assess the correctness and efficiency of a solution using mathematical means. These and other abilities are based on a solid mathematical training. It includes discrete mathematics, formal logics, and an introduction to calculus and real analysis such that students are able to distinguish between ideal mathematical objects and their incarnations on current computer systems. They master not only formal methods to infer conclusions from facts but also the statistical methods to detect patterns in large data sets. Finally, graduates not only have a large repertoire of means and methods at their disposal; they are also aware of the limits of algorithmic and formal methods.*

Design and implementation abilities are described in a similar way. They include programming skills and the mastering of the software development techniques and tools. The technological competences specify the body of knowledge in computer hardware, architecture, operating systems, computer security etc. Beyond the subject specific competences, more general, social skills to be acquired by computer science graduates are described in a similar generic way: Graduates have learned to develop solutions in teams; they can communicate their solutions both in writing and orally; graduates of a Master's program have obtained an introduction into the scientific methodology of the discipline and are able to acquire new knowledge from scientific literature. They are able to organize and monitor projects.

It should be clear that such a description of learning outcomes does not necessarily lead to a unique curricular structure but may result in a large variety of different programs. The accreditation practice, however, has shown that the diversity is much less distinct than one might expect. Despite all local characteristics, undergraduate programs in informatics/computer science at German HEIs often look quite similar: About 30 ECTS

credits are spent for mathematical training including discrete mathematics, calculus, formal logics and stochastic. There is an introduction into computer hardware and architecture, algorithms- and data structures, and computer systems including operating systems, networks, and database management. The strongest emphasis is laid on the introduction into programming and software development including project work, where students not only learn the basics of software technology but also gain practical experience in their application in small teams of 6 to 10 students.

There are several reasons why undergraduate programs often look quite similar: often, informatics departments would base the design of their new Bachelor's and Master's programs on the established one-cycle degree programs instead of starting from scratch; also, they would consult the recommendations of scientific and professional organizations like ACM/IEEE and GI for designing Bachelor's and Master's programs; and accreditation is based on a peer review of programs which means that experts from other HEIs and from industry discuss the concept and its realization with the members of the informatics department. Diversity is much more visible in the Master's programs. Here, the traditional German view, comprised in the traditional one-cycle informatics diploma, of granting a unique universal degree enabling their degree holders for a large variety of different jobs, has been replaced by a variety of highly specialized Master's programs ranging from media informatics, bioinformatics, technical informatics, security systems, to software technology, and many more.

Informatics/computer science is a subject offered at all three major categories of HEI: universities, universities of applied sciences (UAS), and universities of cooperative studies (BA). All HEIs grant Bachelor's degrees, at least in some states like Baden-Württemberg. Universities and UAS also grant Master's degrees. Formally, all degrees are considered to grant equal rights. This is new in the German system of HE. Before, only the Diploma degrees granted by universities qualified their degree holders to enter a PhD program. Now it is possible to switch between institutions with a Bachelor's degree in order to enter a Master's program and to enter a PhD program with a Master's degree regardless of where it has been acquired. It should be obvious that this has been a massive gain in prestige for the UAS. This change was politically intended and is one reason why UAS were much faster than universities in adapting the new two-cycle Bachelor's and Master's system and in seeking accreditation of their degree programs. The only difference remaining between universities and UAS is that the latter ones cannot grant PhD degrees. Nevertheless, the accreditation process has the effect that the educational standards of CS education at universities and UAS are becoming similar, though both still try to maintain their specific profiles: Universities concentrate more on the methodological and theoretical foundations of the discipline while UAS see their strength in the more practical aspects of the discipline and their close relationship with industry.

2. Challenges to applying the Bologna reforms at the University of Freiburg

The University of Freiburg (officially called Albert-Ludwigs-Universität Freiburg named after its founder, Duke Albert Ludwig) is a classical German research university already established 550 years ago in 1457. Today it belongs to the top tier of German universities with proven excellence in research and teaching. It is structured into 11 faculties: Theology, Law, Economics, Medicine, Philosophy, Philology, Mathematics and Physics, Chemistry, Biology, Forestry, and Applied Sciences. It offers 151 different subjects ranging from large subjects like German, to exotic and small subjects like European Ethnology. The structure and organization of this university poses several challenges to the implementation of reforms in higher education.

Heterogeneous program structure

More than half of the degree programs and almost half of the 20,000 students of the university are studying programs not affected by the Bologna reform. These are the state controlled educational programs in medicine, law, and all subjects qualifying students for becoming high-school teachers. Diploma degrees have traditionally been granted in all science and engineering disciplines, but they have to be replaced by the new programs. Thus, there is a discrepancy between the two educational systems, the state-controlled programs and the ones under the sole responsibility of the university. A large number of subjects (like mathematics, for example) may be studied in both modes leading to different degrees. It should be clear that the university tries to utilize synergies between the two programs wherever possible by mutually using identical courses in both programs. However, it turns out to be quite difficult to synchronize the different modes; transition and examination regulations vary, and the objectives of the degree programs differ.

Because of these structural differences, the change of degree programs to the two-cycle system of Bachelor's and Master's degrees at a full university with a broad spectrum of subjects is by far more complex than the corresponding change at a UAS or even at a more homogeneous technical university. Therefore, it is not surprising that most faculty members and study deans were quite hesitant implementing the change.

Heterogeneous information systems

What also has not been considered was the very heterogeneous software environment at the university. The switch to the bachelor/master systems created major headaches for the technical and administrative departments; In particular, they were not flexible enough to handle the large number of course-related exams in the Bachelor's and Master's programs instead of the few punctual exams in the diploma programs. Furthermore, the new examination regulations contain a lot more differentiations and regulations. Those are, for example, the specification of compulsory and elective subjects, keeping track of the numbers of required exams, the number of attempts as well as the introduction of a bonus and malus system. Additionally to the requirement to enter all this information in software systems there is also the need to be able to view the study progress for every student at any time. Therefore, new web-services for supporting the examination authority and the students alike had to be introduced. They should allow every student to retrieve his study progress at any time. First calculations in 2005 showed that the additional effort for manually administrating all the new exams for the students at the University of Freiburg amounted to additional work for six people employed full time for one year (counting 5 minutes of additional work per exam) [9]. Therefore, the software environment had to be prepared to the new system allowing a decentralized maintenance of all the students' data. The University of Freiburg addressed this problem with an infrastructure of a centralized service allowing decentralized administration within the university. Since the beginning of the transition to the new system, the software systems have been improved step by step, but they are still far away from a perfect solution. For example, most of the basic information in the course manual needed for the accreditation (see section three) as well as the data about the staff members and their research experience and current research fields are all stored in one of the universities software systems. From a technical point of view, it should be no problem to collect all this required data and to bundle it for the accreditation. Unfortunately, due to the heterogeneous nature of those software systems, they are not all interconnected which makes it quite hard to get the required data.

The "unknown" first cycle graduates

The common structural framework set in place by the state ministers for higher education stipulates that Bachelor's programs must lead to a professionally relevant qualification. Access to Master's programs must be based on further criteria, i.e. only those students having passed the Bachelor's exam with a result above average are allowed to enter a Master's program. However, where CS is concerned we know that students holding a Bachelor's degree have no difficulties to find a job, at least in the current economical situation. Furthermore, the assumption that the good students stay on and continue their studies in the Master's program is also not universally true. Most of our own graduates entered the industry workforce or changed to another university. Some of them returned after a short period in the industry to continue their studies in a Master's program.

"Soft skills" as explicit element of higher education

In order to qualify the students enrolled in a Bachelor's program for a job, not only a thorough education in the subject is necessary but also the acquisition of so-called "soft skills". These include the ability to work in teams, scientific reading and writing, presentation competences and the mastering of the appropriate computer-based tools, etc. This is also quite new for a classical university. Freiburg has solved this problem as follows: It has established a central unit organizing and teaching a broad spectrum of courses in four different categories: management, communication, media and computer usage, and foreign language education. Each bachelor program must contain between 8 and 12 ECTS credit points taken from this list in order to assure that the students obtain at least a basic training in these soft skills. Beyond this "external" training, informatics students are usually required to complete seminars and project work within their subject also providing such "soft skills" as a by-product.

Every informatics/computer science graduate should be able to solve real-world problems outside his own discipline. For that purpose, he should have learned to communicate with experts from other disciplines and apply his knowledge appropriately. In Freiburg, as in most other universities, this has been solved in such a way that informatics students are requested to enroll in a number of courses from some other discipline, the so called application area. A traditional university has much to offer in this respect: In principle, students may choose any subject of their interest ranging from medicine to business administration and micro system technology. In practice, it has, however, turned out that this was very difficult to organize: it requires special agreements with other faculties, a coordination of the class schedules and examination rules, a compensation for the teaching loads, and much more. Because the Informatics/Computer Science Department was among the very first departments who changed their degree programs to the new two-cycle system, it turned out to be almost impossible to import a limited number of modules from other programs into the informatics program.

General reservation against accreditation

For faculty members bearing in mind the Humboldtian ideal of a university teacher, combining excellence in research with excellence in teaching, the transformation of traditional research-oriented *Diploma* degree programs into a two-cycle structure and the requirement of subjecting the new programs to regular reviews "from the outside", is a radical change to which they find it difficult to adapt. At the University of Freiburg there are a total of

151 programs (in which a total of 20.714 students[2] is currently enrolled). Only 10 of these have already been accredited: four programs in the Computer Science and Microsystems department (see next chapter), one in medicine (Master Online Periodontics), two in economics (MBA International Taxation, MBA Estate Planning), a global studies program (MA Social Sciences) and the programs Environmental Governance and Forest, Ecology and Management. For all of these programs, the higher education ministry of the state of Baden-Wuerttemberg (BW) required the accreditation either before the programs started or after a certain time. Also, all of them receive direct funding from the state ministry for higher education, giving the ministry more leverage than in cases where the funding is provided indirectly via the university as an institution.

As we will see in the next sections the accreditation process is quite time-consuming and sometimes difficult, but certainly worth it for some of the benefits gained by a peer review of the programs.

3. Design and Accreditation of Computer Science programs

Degree programs in informatics/computer science are offered by the Faculty of Applied Sciences, which consists of two departments, the Department of Computer Science and the Department of Microsystems Technology. The Faculty of Applied Sciences in Freiburg already decided in 2004 to suspend the informatics one-cycle Diploma degree program and to introduce new undergraduate and graduate programs. At the time, there was almost no experience at the university with the new two-cycle educational system and accreditation of degree programs. There was, as yet, no accepted framework for new Bachelor's and Master's programs. The aim of the department was to guarantee that the consecutive combination of the Bachelor's and the Master's program should lead to a qualification at least comparable to the old diploma studies. This is in concordance with the definition of so called consecutive Master's programs: The general rules of the Standing Conference of the Ministers of Education and Cultural Affairs of the 16 states in the Federal Republic of Germany for the introduction and accreditation of Bachelor's and Master's programs [7] distinguish between consecutive, non-consecutive, and continuing educational master programs. A consecutive Master's program extends, deepens, and continues its preceding Bachelor's program. Thus, both the undergraduate and the graduate program are considered as a combined unit of coordinated modules leading to a clearly specified common profile. Therefore the idea, when introducing the new programs at the department, was to replace the diploma by a consecutive undergraduate and graduate program in informatics.

The design of the new programs and the accreditation procedure was quite a new experience for the faculty. In particular, the concentration on learning outcomes for the design and implementation of the new programs was completely unfamiliar to the staff. Two main questions had to be answered: How do we achieve the professional qualification of our bachelor students and what are typical jobs for a bachelor graduate? Hence, what is the desired learning outcome? Of course the general requirements, procedural principles and subject-specific criteria mentioned in section one of the accreditation agency had to be fulfilled for a successful accreditation of the new programs as well. This implied the collection and preparation of a lot of information. The output orientation forced explicit formulation of the objectives of the educational programs and not only to derive the curriculum from the objectives but also to show the contribution for each module to the successful achievement of the desired learning outcome.

[2] In winter semester 2007/2008 20.714 students were matriculated.

Another challenge was the requirement that the Bachelor's degree must enable its holders to successfully apply for a job outside the HEI. This meant that the traditional concentration of engineering and science studies at universities on a thorough mathematical training in the first two years could not be maintained anymore. Instead, in the undergraduate program the practical parts, inclusive the procurement of "soft skills", were considerably strengthened, and the mathematical components and advanced topics were only marginally and exemplarily included. Parts of them had to be shifted to the Master's program. The latter fact was also the source of a conflict which seems to be typical for universities transforming their diploma studies into new undergraduate and graduate programs: Traditionally, in the diploma degree programs at universities each core subject (in Germany usually represented by a chair) was represented by at least one advanced course for third and fourth year students; usually there is no specified order in which these advanced core courses have to be taken. The successful completion of these courses is the prerequisite for any further specialization in specific related subjects. The question now was which of the core and special courses should be included into the three years of the undergraduate program and which into the graduate program. In Freiburg (as in many other university departments) this conflict could not be solved amicably. It required a discussion of the staff with the peers during the accreditation audit in order to find a solution and to mostly eliminate this problem, leaving a marginal rest: Courses on software technology and on database systems were turned from electives to compulsory; only very few modules became eligible both in the undergraduate and graduate programs.

When designing the new graduate program, the faculty also wanted to attract students from other universities already holding a Bachelor's degree. Students from abroad already enrolled in an international Master's program (applied computer science, ACS, funded by the German Academic Exchange Service, DAAD, and offered by the faculty for several years) were of particular interest. Originally, it was the aim to merge this international ACS program and the new Master's program. During the accreditation procedure it became clear that this merger was not compatible with the requirements for consecutive degree programs. Therefore, the faculty decided to split the Master's programs into two variants: The consecutive "standard" program and a new non-consecutive ACS program. The latter has special conditions for enrolling students holding Bachelor's degrees from institutions offering degree programs having some overlap with the Bachelor's program in Freiburg but which are not almost identical. In order to allow for the previously gained knowledge of these "external" students and to adapt the level of qualification, the new ACS program was endowed with two new bridge modules providing students with the necessary knowledge enabling them to enter the advanced master courses. That is, both the standard consecutive graduate program and the new non-consecutive ACS-program share large parts of their curriculum but are not identical.

All the modules in the curriculum had to be described within a course manual which consists of a detailed description of each course: The ECTS credits awarded for this course, a detailed list of the workload (time to spend on the practical parts, theoretical parts, lab sessions, homework etc.) the language and type (major, minor, elective course, etc.), the role of the module in the curriculum (i.e. one of four elective modules in a certain area), the requirements, goals and learning contents as well as the kind of exam of the module and of course literature accompanying the course. The most difficult part here was that staff members were not used to distinguish between learning outcomes and the description of the learning input, that is, of the content of a module. Quite often, a professor specified the competences to be acquired by a module simply by "the goal of the course is to obtain an introduction to ... (and then the content description was repeated)". For all modules the learning outcome had to be specified in terms of knowledge (the ability to recall or remember

facts without necessarily understanding them), comprehension (the ability to understand and interpret information), application (the ability to put ideas and concepts to work in solving problems), analysis (the ability to break information in its components to see interrelationships), synthesis (the ability to use creativity to compose and design something original) and evaluation (the ability to judge the value of information based on established criteria) [6]. Moreover, it was necessary to eliminate overlaps and to close gaps in the contents of modules. This, of course, first means that a professor offering a course is himself conscious about the learning outcome and the appropriate method to reach it.

The workload specified in the course manual has to match the total amount of time a student spends on the different modules while he is enrolled in a course. To get a Master's degree in Baden-Württemberg, students have to take courses for a total of 300 ECTS credit points (including the credits gained during their first degree – i.e. bachelor). This corresponds to a total number of 9,000 hours of student work load (1 ECTS credit point awarded corresponds to 30h work). This workload and its related burden for the student (which is often underestimated by students) have to be monitored continuously. In this way the student is not overworked, but the workload should also not be too low during a semester. The required amount of work and other factors like the quality of teaching should be evaluated at least every semester to make sure that the quality fits the expectations one would have from a top tier university. This includes student's critics of courses. In the Master's program "Intelligent Embedded Microsystems" (IEMS) we evaluate courses twice a semester (once in the middle to be able to intervene if something goes wrong, and once after the exams to get accurate/detailed feedback from the students about the real workload they had with the modules including the time they spent on preparing for the exam).

The major problem here is that every faculty or department used to have its own style of using evaluations to implement some kind of quality monitoring. Today the University of Freiburg is establishing a general evaluation framework for the whole university in order to assure a continuous and standardized evaluation of all courses in every faculty. Quality control is also a requirement for the accreditation of the degree programs and therefore there is no need that every faculty starts from scratch. But the standardization of all different faculties needs for evaluation is almost impossible. What fits the Computer Science Department needs does not fit the needs of the Psychology Department and vice versa. A cautious legal department caused additional problems by rejecting the drafts for an evaluation regulation because they allegedly were conflicting with legal provisions.

Since Master's programs should have a clearly visible research orientation, curriculum design cannot be independent from the research activities of the staff members responsible for the program. Therefore, a meaningful detailed description of the professional experience, the areas of research, and role of all the people involved in the program had also been compiled for accreditation. It is not surprising that this was one of the easier tasks, for professors of a research university which are accustomed to present themselves and their research achievements.

Of course, also the basic formalities for any degree program, like admission regulations, regulations for exams, form of the diploma degree, and the diploma supplement had to be formulated and approved by the university committees. Creating these regulations without the existence of a framework for Master's/Bachelor's degree programs at the university was arduous but not impossible. Today the University of Freiburg has a general framework for all Bachelor's and masters' programs; it is based on the experience gained in the establishment of the informatics/computer science programs and considerably facilitates the introduction of new subject specific programs.

Currently, the Faculty of Applied Science with its two departments, the Department of Computer Science and the Department of Microsystems Technology, offers a bachelor program in informatics and two master programs (consecutive and non-consecutive) in informatics as well as bachelor and master programs in microsystems technology. Both departments have a special research focus on intelligent systems and in the field of embedded microsystems. They have all the technologies and know-how available necessary to design and develop modern high-tech embedded systems. Therefore the faculty decided to also offer a new graduate program in this field as a program for continuing education, the Master's program "Intelligent Embedded Microsystems" (IEMS). The idea for this new program was not only to combine the expertise of the two departments but also to utilize the long experience of the faculty in the usage of networked computers and multimedia for establishing online versions of their study courses. As already mentioned, the Bachelor's degree from German universities of applied sciences (UAS) and universities of cooperative studies (BAs) now gives students the possibility to enter a Master's program at a university. In order to broaden the reservoir of potential graduates for the new Master's program, and, in particular, in order to attract students who have already worked for some time in industry after their graduation, the curriculum of the master IEMS has been designed to accept all kinds of different students from these institutions [1]. The establishment of this new Master's program IEMS has been supported by a generous fund from the State Foundation BW. This funding, however, was combined with the requirement to accredit the degree program before its introduction.

Fortunately, the accreditation of the new Master's program IEMS was a lot easier. The complete documentation describing the resources available for implementing the program, like staff, buildings, equipment etc. could be reused. So the biggest hurdles were mainly the concept of the degree program, the mode of its realization, the detailed description of all modules, and the regulations for admission and transfer from other programs.

After delivery of the whole documentation to the accreditation agency, a group of four peers, all specialists in the related fields, carefully studied the material provided. They then visited the department in order to discuss the new program, its goals and implementation as well as the studying conditions for the students with the professors involved in the program.

During the first audit of the computer science bachelor program it was criticized that the given ECTS credits did not reflect the correct workload of the students and that the qualification profile of the bachelor students was too blurry. The audit of the master IEMS was similar: The peers detected a number of inconsistencies, overlaps, and gaps in the program and helped to sharpen its profile. Moreover, there were some singularities involved in this IEMS program requiring special attention: First, the degree program is designed as a Master's program for continuing education. This means, that its modules and the mode of instruction should relate to the acquired professional experience of students. Second, it should be possible to study the program part-time and enable the students to stay in their job with a possibly reduced workload. Third, the study mode is blended learning, which is a mixture of online delivery and present studies. Many modules are based on newly compiled lecture recordings and enriched with other study material like self-assessments and a study guide. The special delivery mode for the content required us to show the lecture recording rooms where the recordings are taken and the laboratories where students can do practical lab sessions. The peers were quite impressed by the professionalism on how lecture recordings [3] are produced at the faculty and how they are delivered via a learning management system. Even some labs are organized as online labs [2], something quite unusual for such degree programs. As a result of the peer review and the audit, accreditation was made pending on only very few improvements: Overlapping contents in two courses had to be removed, in some others the contents had to be clarified, two new modules had to be introduced (control theory, actuators), and some of the detailed module descriptions had to

be revised. For all modules, a responsible contact person had to be nominated, and detailed module descriptions had to be created for each project management module instead of a general description of project management modules.

The result of the whole accreditation processes was a considerable improvement and a much better coherence of the whole program. Thus, the faculty has many reasons to appreciate the careful and thorough work done by the accreditation agency and the peers.

4. System accreditation versus program accreditation

The introduction of system accreditation as an alternative to program accreditation is a recent development. The German Accreditation Council has developed system accreditation as a new instrument of external quality assurance for higher education degree programs in 2007 in order to address several problems that had been identified by HEIs and several state ministries for higher education.

On the one hand, it was found that program accreditation as practiced since 2000 was a costly process, both in terms of financial and personal resources: These encompass external costs for fees charged by accreditation agencies as well as internal costs associated with preparing the required documentation. The fee charged for an accreditation process for a single degree program or a consecutive Bachelor-Master-combination is about EUR 11,000 to 12,000, when more related programs are reviewed within one joint procedure, the average cost per program is about EUR 3,500 to 4,000. Additional costs of the accreditation process were caused by the compilation of the self evaluation and additional documentation: since almost no German HEI had pre-defined processes or dedicated administrative staff for quality assurance, and heterogeneous information systems did not provide coherent data on student success, it was most often left to academic staff to compile the required documentation by their own hand. Not surprisingly, this was not seen as an efficient use of scarce resources. All the more, because on the other hand program accreditation was not always perceived to have a visible and lasting impact on the quality of the degree programs. All too often, it seemed, the peer review was limited to discussing formalities rather than discussing ways to further improve the quality of the degree programs; when recommendations for quality development were made, HEIs lacked proper instruments for ensuring that they were being followed up upon. From this perspective, and given limitations to the institutions' capacities, program accreditation was criticized as a futile exercise without lasting impact.

To address these problems, system accreditation has been introduced – initially as an alternative to program accreditation but with the perspective of replacing it altogether within five to ten years' time. System accreditation requires HEIs to install a comprehensive quality management system that – at least – covers their core process teaching and studying. In order to receive a system accreditation, HEIs must demonstrate that not only have they designed and installed a comprehensive quality management system in this area, but also its effectiveness, i. e. the QM system must be able to effectively control and guarantee the quality of all degree programs on an ongoing basis. This includes the effective control of teaching quality based on student surveys, the periodic review of program outcomes, the transparent documentation of the programs and of all modules including their contribution to achieving the desired learning outcomes, the efficient organization of the course of studies including the design, administration and registration of exams, research on alumni and their career development, to name a few. Quality management systems suitable for system accreditation must meet the Standards and Guidelines for Quality Assurance in the European Higher Education Area [8], and should be as effective as the external quality control achieved by the program accreditation – in effect, this implies that HEIs assume the functions of program accreditation rather than leaving this task to an external agency. HEIs

that have been awarded a system accreditation are freed from the requirement of having all degree programs accredited individually.

Given the organizational capacities and current state of quality management instruments and processes at most German HEIs (as described above using the – not untypical – example of the University of Freiburg), the road to system accreditation will be a long and winding one for many of them: Universities like the University of Freiburg have just started to establish such a quality control system. They are already routinely collecting quite a large number of benchmark data relevant for quality control. But there are still serious deficiencies and fundamental problems resulting from the fact that many of the involved services and their computer-based support is not organized in an interoperable way. Here, universities will have to invest a lot of energy and money within the near future.

Nevertheless, at least the large research universities in Germany seem to aim for system accreditation instead of program accreditation in the medium term. They also consider this a further indication of autonomy and independence of external control by the state or state-governed institutions. Furthermore, organizing their own quality control system facilitates the combination of teaching and learning assessments with research assessments, also to be periodically carried out every five to seven years.

5. Lessons learned

The biggest advantage of the accreditation process of the new undergraduate and graduate programs is that faculty members are obliged to seriously discuss the teaching and learning objectives in their departments; the competence profile expected from their alumni by their future employers and not their own (research) interests dictates the design and implementation of a degree program. All our experiences show that external peer reviews are the most efficient means to initiate the necessary change from the input to output orientation and to guarantee the quality of degree programs. The requirement to document the objectives, the learning outcomes, and the contents of a curriculum in the accreditation procedure implies that accredited degree programs are usually much better documented than non-accredited ones. This is of special benefit for students, future employers, and staff members alike. The additional expenditure for the accreditation appears to be worth the effort; it is assuaged if the university offers well-developed computer-based services for staff and students supporting all phases of studying at a HEI. Currently, we see the greatest deficits in this respect. Though universities have a large number of web-based services supporting students and staff, these services are seldom interoperable, well integrated, reliable, secure, and user friendly enough in order to fulfill current and future needs. If quality control by accrediting a degree program is not considered an isolated event to be carried out every five or seven years but understood as a continuous process, universities must be able to provide benchmark data a mouse click away. Information about success and failure rates of degree programs, acceptance of their alumni by the job market, workload of modules and results of course-related exams must be easily available.

The emphasis on learning outcomes and competences to be acquired in the new degree programs designed after the Bologna reform also raises new challenging questions for faculty and scientists alike: How can we measure the competences? What are the best means to achieve the desired learning outcomes? Are our courses, labs, seminars the appropriate, the only means to achieve a defined competence level? Are there other ways to reach a competence level comparable to what universities can offer? How can the university contribute to the life-long learning process of continuously refreshing the competence of their alumni? The modularization of the new degree programs should facilitate this quite a bit: Universities may allow interested students to enroll in single courses which are of current interest for industry irrespective of whether the applicant for participation has an appropriate degree. Once he can show that he has the necessary competence to follow the course, he

could be allowed to enroll. If he succeeds, the university may issue a certificate but not (another) degree to him.

Finally, though most large (research) universities currently go for systems accreditation instead of program accreditation, we see that most of them have still to go a long way until a reliable and effective internal quality control system is operational. We do not expect that its successful implementation will make procedures like the current program accreditation obsolete. It is expected that they may become easier to handle and less cumbersome; but we anticipate that their essentials remain valid in order to guarantee the quality of current and future degree programs.

References

1. Hermann C, Welte M. Continuing Education at Universities: New Perspectives at German Universities, Informatics Education Europe II, Thessaloniki, Greece, Nov. 2007.
2. Becker M., Hermann C., Welte M. and Manoli Y. "intelligent embedded microsystems" distance learning in microsystem engineering and applied computer science. In EWME 2008 - 7th European Workshop on Microelectronics Education, to appear. Springer.
3. Hermann C., Hürst W. and Welte M. The elecure-portal: an advanced archive for lecture recordings. Informatics Education Europe, Montpellier, France, Oct. 2006.
4. Computing Curricula 2001 Computer Science, ACM/IEEE 2001, http://www.sigcse.org/cc2001/cc2001.pdf
5. Bachelor- und Masterprogramm im Studienfach Informatik an Hochschulen, Dezember 2005, GI Empfehlungen 48, 2005 http://www.gi-ev.de/fileadmin/redaktion/empfehlungen/GI-Empfehlung_BaMa2005.pdf
6. Bloom, B.S. Taxonomy of educational objectives: The classification of educational goals: Handbook I, cognitive domain. New York, 1969
7. Ländergemeinsame Strukturvorgaben gemäß § 9 Abs. 2 HRG für die Akkreditierung von Bachelor- und Masterstudiengängen; Beschluss der Kultusministerkonferenz; 10.10.2003 as amended on 22.09.2005 http://www.kmk.org/hschule/strukvorgaben.pdf
8. Standards and Guidelines for Quality Assurance in the European Higher Education Area; European Association for Quality Assurance in Higher Education; Helsinki, Finland; 2005 http://www.bologna-bergen2005.no/Docs/00-Main_doc/050221_ENQA_report.pdf
9. Kraus M., Trahasch S., Vögele E. and Hermann C. eGovernment-Dienste als Voraussetzung für den Bologna-Prozess. In Proceedings of Multikonferenz Wirtschaftsinformatik, Passau, February 2006. Springer.