UPGRADE is the European Journal for the Informatics Professional, published bimonthly at <http://www.upgrade-cepis.org/>

Publisher
UPGRADE is published on behalf of CEPIS (Council of European Professional Informatics Societies, <http://www.cepis.org/>) by Novática <http://www.ati.es/novatica/>, journal of the Spanish CEPIS society ATI (*Asociación de Técnicos de Informática,* <http://www.ati.es/>)

UPGRADE monographs are also published in Spanish (full version printed; summary, abstracts and some articles online) by Novática

UPGRADE was created in October 2000 by CEPIS and was first published by Novática and INFORMATIK/INFORMATIQUE, bimonthly journal of SVI/FSI (Swiss Federation of Professional Informatics Societies, <http://www.svifsi.ch/>)

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<http://www.upgrade-cepis.org/pages/editinfo.html#newslist>

ISSN 1684-5285

Monograph of next issue (October 2006)
"Web Services"
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UPGRADE
The European Journal for the Informatics Professional
http://www.upgrade-cepis.org

Monograph: The Bologna Process and The Informatics Profession (published jointly with Novática*)

Guest Editors: *Juan-José Cuadrado-Gallego, Luigi Buglione*

UPENET (UPGRADE European NETwork)

Historical Evolution of Courses of Study in Computer Science: A German Experience Report

René Braungarten, Martin Kunz, and Reiner R. Dumke

With the 1999 declaration of Bologna the 29 European signatory nations intended to harmonize higher education in Europe thereby introducing modern concepts e.g. the modularisation and quality assurance of courses of study, Bachelor and Master programs, a comprehensible system of credit point quantitation of student's efforts to attend and complete the modules. In many European countries those modernisation concepts were not easy to start because of the historical particularities of each country. Therefore, this paper picks out the example of the Federal Republic of Germany, describes the historical point of departure in harmonizing higher education and tries to mirror its evolution in Computer Science studies in recent years supported by respective normative references. Finally, the paper gives an overview of the latest related developments, according to what has become known as the Bologna-process, which are aligned with enabling regulations for German higher education.

Keywords: Accreditation, Bologna-Process, Computer Science, European Credit Transfer System, Germany, Modularization of Course of Studies.

1 Introduction

The initiative to establish and/or harmonize a European Area of Higher Education (EAHE) started by the declaration of Sorbonne, which was signed by the Ministers of Education of France, Italy, United Kingdom and Germany in 1998. Roughly one year later, in 1999, representatives of 29 European countries signed the declaration of Bologna, which is the well-known synonym for the whole process of reformation in the area of higher education. The Bologna-process entails broad changes especially for the education scenery of German universities. Those changes have not only had an effect on the structure and contents of the courses of study, but also on the organisation of the universities and universities of applied sciences as well as on their administrative processes.

Most probably the largest challenge for the institutions of higher education, and for the students involved, is the ongoing reorganisation of courses of study from traditional "*Magister*" or "*Diplom*" to modern and European-wide, consistently handled, Bachelor and Master programs. The connected modernisations deal amongst other areas with the accreditation of reorganised courses of study through quality assurance in education, with their modularisation and with the implementation of the European Credit Transfer System (ECTS). Another important fact is the certification of diploma-supplements according to the European Diploma Supplement Model (EDSM). To characterize the progresses in Germany this paper is intended to describe, how complex the historical development of higher education in Germany was, what changes took place immediately, and how the Bologna-process is being implemented until 2010.

The remainder of the paper is structured as follows: Section two describes the historical evolution of higher education in Computer Science in Germany, while section three describes the efforts that have already been made to date with the help of a case study. Section four delineates how

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courses of study in Computer Science have been reorganised at the case study site to meet the guidelines of the Bologna-process. Finally, section five concludes the paper.

2 Historical Evolution of Higher Education in Computer Science in Germany

2.1 Higher Education Development until 1990

The courses of study nowadays offered to German students represent grown structures, whose evolution is obviously aligned with the political development in Germany. It started with the division of the occupied Germany after World War II by the Allied Forces and with the foundation of two states on German territory. By the proclamation of the Basic Constitutional Law the Federal Republic of Germany (FRG) was founded on 23 May 1949 on the territory occupied by the western Allies, namely the United States of America, United Kingdom and France, including the western part of the primary capital, Berlin. Later that year, on October, 7 the German Democratic Republic (GDR) was founded on the territory occupied by the Soviet Union. The opposed ideological orientations of the FRG as a social market economy (capitalism) and of the GDR as social, central planned economy (socialism) were forced and promoted by the respective occupying powers. Finally, these contradictions lead, step by step, during the time of "Cold War" to the physical division of Germany into the East Germany and West Germany, which became final with the construction of the Berlin Wall on 13 August 1961.

Until the political turnaround in autumn 1989 that peaked with the opening of the Berlin Wall on November, 9 1989 and with the final German reunification on 3 October 1990, the organisation and concepts of higher education in both German states strongly diverged. Because of that a short summary for each state is provided beneath.

2.1.1 Situation in West Germany (FRG)

Normative references

With the 1969 amendment of the Basic Constitutional Law of the FRG, which was ruled at that time from its new capital, Bonn, by article 75, paragraph 1, number 1a, the final legislative power for art, education and science had been assigned to the eleven federal states of the FRG. [1] That assignment of regulatory power meant that the federal government could only provide "*general guidelines for higher education in Germany*" by means of a Higher Education Framework Law (HEFL). However, the respective federal states could implement that regulation with the help of their own Federal State Higher Education Laws (FSHEL). The format of the 1969 HEFL of the FRG regulated in different chapters such as the tasks of universities and universities of applied sciences in studies and teaching, or the admission of students to courses of study [2].

From that time on it was generally possible in the FRG to attend a non-chargeable course of study, directly or remotely, at universities that offered thorough and rather theoretical education in so-called "*Diplom*" programs, or at engineering schools that provided an education being immediately aligned to later job practice. The latter schools were renamed in 1970 to universities of applied sciences and offered a first scientific grade of "*Diplom*" with the mandatory appendage "*FH*" (that is: awarded by a university of applied sciences) qualifying students for the job. [3] Simultaneously the HEFL of 1973 split courses of study into two cycles: basic studies and advanced studies. Withal, the targeted standard period of study at universities was four and a half up to five years, while the programs at universities of applied sciences should last three years at minimum and no longer than four years. Moreover, the successful performance of scientific studies, research tasks and the preparation of an extraordinary dissertation could be awarded with the Doctor's grade appended by the respective discipline's name.

Usually, universities in West Germany normally awarded the completion of a course of study in social or natural science with a "*Diplom*" grade and, as special case of the HEFL, awarded the successful completion of courses of study in humanities with a so-called "*Magister Artium*" (that is: Master of Arts). Over and above, many universities offered accredited courses of study for teachers, health professionals or medical doctors and lawyers that led to a degree after successfully passing two stages of governmental examinations ("*Staatsexamen*"). In contrast, a study program at non-governmental universities or private business academies did not lead to an academic grade but to a nationally approved job designation.

Computer Science Education in West Germany

In 1968, the Minister for Research of the FRG, Stoltenberg, made a speech in Berlin, at a conference jointly organized by the Technical University of Berlin and the Massachusetts Institute of Technology (MIT), and referred for the first time to a new science called "Computer Science". Thereupon in the same year and with the help of a national support programme the Technical University of Munich, the Technical College of Karlsruhe, and one year later the Technical University of Berlin, led the way for higher education in novel courses of study in Computer Science. These institutions started with a program strongly aligned with mathematics at especially founded faculties. While the curricula could be organized by the offering universities themselves, the academic grades to be awarded in Computer Science had to be aligned with the prevailing HEFL and were "*Diplom-Ingenieur/in*" (engineer with university Diplom) and/or "*Diplom-Informatiker/in*" (computer scientist with university Diplom).

The universities of applied sciences that offered more practically oriented study programs also enabled interested parties with secondary school leaving certificate or a master of trade and/or technician to study further. They very soon started to offer shortened courses of study in Computer Science; like in Furtwangen many of them offered a program leading to the basic academic grade "*Diplom-*

Informatiker/in" (computer scientist with Diplom) with the mandatory appendage "(FH)" (that is: awarded by a university of applied sciences) [4].

2.1.2 Situation in East Germany (GDR)

Normative references

Contrary to the Basic Constitutional Law of the FRG, being ruled from East-Berlin [5] the constitution of the GDR attributed the authority for the organisation of higher education centrally to the Ministry of Education of the People and to the Ministry of Higher Education. In February 1951, the Council of Ministers of the GDR decided the "Decree over the Reorganisation of Higher Education" [6] and thereby commenced its socialistic reshaping, which became even more precise in February 1970 with the "Decree over the Tasks of the Universities, Scientific Academies and Scientific Institutions of Academic Form" [7].

In analogy to higher education in West Germany, by decision of those decrees it was possible to attend a non-chargeable study program, directly or remotely, exclusively at national universities or engineering schools. While the universities also offered programs for the academic degree "*Diplom*" that should be finished within five years and qualified students for a job, the engineering schools offered programs for the basic academic grade of an "*Ingenieur*" (engineer) with drastically shortened standard period of study. The mentioned decrees also decided the fragmentation of courses of study into three parts: basic studies, study of a special subject and research study. Those decrees included special cases where occasionally the award of a Doctor's grade was allowed where study in the pertinent discipline had been enhanced by a combination of extraordinary scientific studies, research results, the preparation of a dissertation and diverse political activities.

Computer Science Education in East Germany

Originating from mathematical study programs and involved sciences like physics or chemistry, allowing the study of Computer Science was connected with the obligation to support the centrally planned economy of the GDR with skilled personnel that had been trained according to modern standards of higher education. Initially the Technical University of Dresden led the way for higher education in Computer Science in the GDR by the creation of a special faculty, called "*Sektion Datenverarbeitung/Rechentechnik*" (section data processing/computer engineering). [8] In 1969, parallel to the development in the FRG, 157 students were enrolled in a direct program, from which 113 alumni eventually left that faculty as the first "*Diplom-Ingenieure/innen für Datenverarbeitung*" (engineers with university "*Diplom*" in data processing) at the end of the 1973 academic year. In a few years it also became possible to attend simplified programs in Computer Science at assorted national academies and engineering schools, which awarded a successful completion with the basic academic degree "*Ingenieur für Datenverarbeitung*" (engineer for data processing) [9], whose degree and curricula roughly corresponded to those of the universities of applied sciences in the FRG. Shortly before the political turnaround in the GDR in 1986, the political leaders enhanced the number of universities being allowed to offer higher education in Computer Science to the university sites of Magdeburg, Rostock, Ilmenau and Karl-Marx-Stadt (today Chemnitz). In a pioneering move in 1987 the GDR's Ministry of Higher Education founded a "Syllabus for Postgraduate Program to Qualify Teachers with University 'Diplom' in the Area of Computer Science at Universities and Academies of the GDR" [4].

2.2 Combination of German Higher Educations Starting From 1990

After the Contract of the German Reunification [10] which regulated the incorporation of the GDR as five new federal states into the FRG starting from 1990 and lasting until recent years, both German higher education systems also had to be consolidated. This process was turbulent and advocators had to overcome numerous difficulties as it is usual when putting together two contrary systems. But the basic principle of higher education at universities, with a "*Diplom*" grade aligned to longer research, and the "*Diplom (FH)*" grade aligned to the practical, shortened higher education at universities of applied sciences, were finally adopted for the combined system of new FRG. Coevally, the fragmentation of courses of study into basic studies and advanced studies had been taken across. However, West Germany's principle of concurrent legislative power between the federal government and the respective federal states was adopted, too, and caused some serious irritations to those used to be centrally governed.

In the course of separating higher education from imparting political opinions or beliefs, unportable and politically prejudiced teaching personnel was removed from universities on the territory of the former GDR an replaced by politically neutral staff. This process also caused serious trouble, since the categorization of teaching personnel into prejudiced or open-minded was not in all cases fair and represented sometimes (at least felt) arbitrariness.

In order to enforce the legal approval and to be able to handle equivalent grades equivalently, the degrees awarded by higher education in the former GDR were accepted and equated by decision of the Combined Board of Ministers of Education of the 16 federal states of the FRG [11].

3 First Efforts to Reform Present Computer Science Courses of Study

For a long time, and for many reasons, Germany has been the straggler in the European scenery of higher education. Probably the most difficult was – and still is – that the concurrent legislative power of federal government and federal states in questions of education provided complex and protracted ways of making decisions. Furthermore, there was scepticism in Germany whether increasing the ratio of students in the educational system from 30% in Germany to the European standard of 50% would make sense.

Also the German system of higher education had to revise its structures so as not to loose attractiveness to foreign students because of its inadequately structured curricula and comparatively long standard periods of study. Additionally, German academic grades of higher education suffered from being not known or from being not even accepted. In spite of its role of a straggler, Germany caught up rapidly and acted as one of the initiators of the Bologna-Process in 1998. When the HEFL was amended in the same year, a discretionary clause allowed the normative preconditions for the introduction, on a trial basis, of Bachelor and Master programs in Germany [12].

3.1 Case Study: Start of the Reformation at the Otto-von-Guericke-University

The FSHEL of the pertinent federal states that underlie the conditions of study and examination regulations at institutions of higher education were geared to the HEFL of the FRG in its latest form of 2002 [13] and merely differ marginally from each other. Because of that a representative case study of courses of study in Computer Science at the Otto-von-Guericke-University Magdeburg (federal state of Saxony-Anhalt) is used as an example and supported by excerpts of the related documents which are aligned to the FSHEL in force. [14] However, before that alignment can be described, it is necessary to define the preconditions which qualify for admission to higher education in Saxony-Anhalt.

General Admission to Courses of Study

With the 2002 Higher Education Qualification Decree (HEQD) of Saxony-Anhalt the general preconditions for admission to courses of study have been codified. In order to start studying at a university, according to part 1, paragraphs 1 to 3, potential students are required to hold a general qualification for university matriculation from a German secondary school that enables one to enrol in any desired course of study. Beyond that it is also possible to matriculate at a university with qualification for university entrance from a German secondary school that is restricted to a special category of subjects. However, the latter method only qualifies for enrolment in courses of studies with curricula based on that special category. In part 2, paragraphs 4 to 7, it also regulates the precondition to study at universities of applied sciences, with the exception of special cases like grades awarded by universities of German Federal Armed Forces or a master of trade and/or technician, at least an advanced technical college entrance qualification has to be held. Of course, students fulfilling the preconditions for university programs also qualify for studies at those educational institutions. [15]

Offered Courses of Study in Computer Science

Currently, interested and qualified first-year students can choose between one of the following courses of study in Computer Science at the Otto-von-Guericke-University Magdeburg: intrinsic Computer Science, Computational Visualistics, Computer Systems Engineering, or Commercial Information Technology. They can complete their studies with either the academic basic qualification of a Baccalaureate (that is: Bachelor) after a standard period of study of seven semesters (3.5 years), or the traditional German university "*Diplom*" after ten semesters (5 years). Those courses of study represent part of the changes to the traditional system of higher education according to the discretionary clause of 1998.

The different curricula which can be gathered from the related conditions of study are briefly presented here in Tables 1, 2, 3 and 4.

4 The Bologna-Process: Fundamental Changes to Higher Education in Computer Science

In October 2003 the Combined Board of Ministers of Education of the 16 federal states of the FRG decreed binding specifications as a framework for the introduction of a staged structure of study [16]. This excluded the nationally approved programs requiring governmental examinations ("*Staatsexamen*") e.g. for medical doctors, teachers, or lawyers, as well as theological and artistic programs from the shift to the two cycle Bachelor/Master courses of study. However, until now 11 of 16 federal states decided to convert those programs towards the staged structure of study. [12]

4.1 General Binding Specifications of the Combined Board of Ministers of Education

The implementation of the Bologna-process and the related committing regulations within Germany were done to alleviate the shortcomings depicted earlier and to better integrate the country into an EAHE. As a result, the Bachelor's degree shall now become the standard degree in German higher education and it shall qualify alumni for a job after drastically reduced standard periods of study. With this arrangement a Master's degree will become unusual. [16]

As a fundamental innovation and "cultural shock" for universities it has been decided that both established kinds of institutions of higher education, universities and universities of applied sciences, are now allowed to offer Bachelor and Master programs, equivalently. So the traditional splitting of basic and advanced scientific studies on different institutions that lasted several decades has been discontinued.

Accreditation for Reasons of Quality Assurance

In order to ensure the quality of the courses of study the pertinent curricula descriptions, conditions of study, and their examination regulations have to be approved by special boards organized by the Ministries of Education of the different federal states. In the course of those accreditations a classification of every Master program into "rather geared to research" (university) or "rather geared to practice" (universities of applied sciences) has to be provided by the institutions, but which are not mirrored by the awarded degree. Similarly, during the accreditation process, another

Baccalaureate in Computer Science	HPWS*	"Diplom-Informatiker" ("Diplom" in Computer Science)	HPWS*
Basic Studies (4 semesters)		*Basic Studies (4 semesters)*	
- **Mathematics I and II**	12	- **Mathematics I and II**	12
- **Technical Computer Science I** (Electronic Basics)	6	- **Technical Computer Science I** (Electronic Basics)	6
- **Practical Computer Science** (Introduction to Computer Science , Algorithms and Data Structures)	16	- **Practical Computer Science** (Introduction to Computer Science , Algorithms and Data Structures)	16
- **Logic for Computer Scientists**	6	- **Logic for Computer Scientists**	6
- **Technical Computer Science II** (Computer Systems, Computer Architectures)	8	- **Technical Computer Science II** (Computer Systems, Computer Architectures)	8
- **Mathematics III**	6	- **Mathematics III**	6
- **Theoretical Computer Science**	6	- **Theoretical Computer Science**	6
- **Area to Choose** (Coding and Modelling plus 3 out of: # Practical Computer Science: Operating Systems I, Compilers I, Computer Graphics, Databases I, … # Applied Computer Science: Real-Speech Systems, Simulation I, Visualization # Technical Computer Science: Picture Processing, Real-time Systems, Communication + Networks # Theoretical Computer Science)	16	- **Area to Choose** (Coding and Modelling plus 3 out of: # Practical Computer Science: Operating Systems I, Compilers I, Computer Graphics, Databases I, … # Applied Computer Science: Real-Speech Systems, Simulation I, Visualization # Technical Computer Science: Picture Processing, Real-time Systems, Communication + Networks # Theoretical Computer Science)	16
- **Software Training**	4	- **Software Training**	4
- **Proseminar**	2	- **Proseminar**	2
- **Minor Subject**	6	- **Minor Subject**	6
Sum	***88***	*Sum*	***88***
Advanced Studies (3 semesters)		*Advanced Studies (6 semesters)*	
- **Computer Science I** (4 subjects, one out of each Category: Practical, Applied, Theoretical and Technical Computer Science)	16	- **Computer Science I** (5 subjects, one out of each Category: Practical, Applied, Theoretical and Technical Computer Science, +1)	20
- **Computer Science II**	16	- **Computer Science II** (4 subjects)	16
- **Seminar**	2	- **Professional Practical Training**	20 weeks
- **Professional Practical Training**	20 weeks	- **Computer Science II** (4 subjects)	16
- **Minor Subject**	6	- **Seminars**	4
		- **Laboratory Training**	7
		- **"Diplom" Thesis**	5 months
		- **"Diplom" Colloquium**	2
		- **Minor Subject**	12
Sum	***40***	*Sum*	***77***

* HPWS = hours of effort per week of semester

Table 1: Excerpt of curricula of traditional courses of study in *Computer Science* at the Otto-von-Guericke-University Magdeburg, Germany [17].

categorization for a Master program has to be provided that differentiates between consecutive Master programs, that professionally continue a Bachelor program, and non-consecutive ones and those for further studies. The latter ones are often multidisciplinary courses of study that require potential participants to hold an academic degree and to have a job experience of at least one year. For those, and the non-consecutive Master programs apart from academic grades, even nationally approved occupational titles like MBA, which is one of the titles for graduating students of private universities of cooperative education, may be awarded.

Today, the new repertoire of grades to be awarded ranges from Bachelor/Master of Science, Engineering and even Arts. In addition to every degree's certificate a diploma supplement according to the already mentioned DSM of the

Baccalaureate in Computational Visualistics	HPWS*	"Diplom-Ingenieur" for Computational Visualistics	HPWS*
Basic Studies (4 semesters)		*Basic Studies (4 semesters)*	
- **Practical Computer Science** (Introduction to Computer Science , Algorithms and Data Structures)	16	- **Practical Computer Science** (Introduction to Computer Science , Algorithms and Data Structures)	16
- **Mathematics I and II**	12	- **Mathematics I and II**	12
- **Theoretical Computer Science** (Algorithmic Geometry)	06	- **Theoretical Computer Science** (Algorithmic Geometry)	06
- **Computational Visualistics** (CV 1 and 2)	08	- **Computational Visualistics** (CV 1 and 2)	08
- **Mathematics III and IV**	9	- **Mathematics III and IV**	9
- **General Visualistics** (Design, Pedagogy, Philosophy, Politics, Psychology)	12	- **General Visualistics** (Design, Pedagogy, Philosophy, Politics, Psychology)	12
- **Application Subject**	8	- **Application Subject**	8
- **Software Training in CV**	4	- **Software Training in CV**	4
- **Proseminar**	2	- **Proseminar**	2
Sum	***82***	*Sum*	***82***
Advanced Studies (3 semesters)		*Advanced Studies (6 semesters)*	
- **Computational Visualistics** (3D Computer Vision)	8	- **Computational Visualistics** (3D Computer Vision)	12
- **Computer Science** (Databases I, Introduction to Simulation, Intelligent Systems: Introduction, Technical Computer Science I or Operating Systems or Distributed Systems)	16	- **Computer Science** (Databases I, Introduction to Simulation, Intelligent Systems: Introduction, Technical Computer Science I or Operating Systems or Distributed Systems)	24 20
- **General Visualistics** (Job and Corporate Pedagogy, Design, Pedagogy, Philosophy, Politics, Psychology)	8	- **General Visualistics** (Job and Corporate Pedagogy, Design, Pedagogy, Philosophy, Politics, Psychology)	
- **Application Subject** (Picture Information Technology, Construction and Production, Medical Science, Material Science)	8	- **Application Subject** (Picture Information Technology, Construction and Production, Medical Science, Material Science)	12
- **Seminar**	2	- **Professional Practical Training**	20 weeks
- **Professional Practical Training**	20 weeks	- **Student Research Project**	
- **Thesis of Baccalaureate**	15	- **Seminars**	4
		- **Laboratory Training**	4
		- **"Diplom" Thesis**	5 months
		- **"Diplom" Colloquium**	2
Sum	***42***	*Sum*	***78***

* HPWS = hours of effort per week of semester

Table 2: Excerpt of curricula of traditional courses of study in *Computational Visualistics* at the Otto-von-Guericke-University Magdeburg, Germany [18].

European Union, the Council of Europe and the UNESCO is being issued, which contains not only a description of the kind, level and contents of the attended study program, but also information concerning the status of the educational institution as well as the delineation of the higher education in the FRG [21].

Modularisation and Credit Points

Furthermore the quantitation of credit points aligned with the ECTS has been standardised, now: Per semester 30 credit points have to be reached on average with a related study effort of 900 hours, the mandatory thesis for Bachelor programs is worth 6-12, and the thesis for Master programs 15-30 credit points.

Duration

While Bachelor programs should span over a period between three and four years and require 180-200 credits, Master programs should last between one and two years and need 60-120 credit points for fulfilment. A consecutive Master program may span at maximum over 5 years and require 300 credit points.

Baccalaureate in Computer Systems Engineering	HPWS*	"Diplom-Ingenieurinformatiker" ("Diplom" in Computer Systems Eng.)	HPWS*
Basic Studies (4 semesters)		*Basic Studies (4 semesters)*	
- **Mathematics I and II**	12	- **Mathematics I and II**	12
- **Technical Computer Science I** (Electronic Basics)	6	- **Technical Computer Science I** (Electronic Basics)	6
- **Practical Computer Science** (Introduction to Computer Science , Algorithms and Data Structures)	16	- **Practical Computer Science** (Introduction to Computer Science , Algorithms and Data Structures)	16
- **Logic, Theoret. Computer Science**	6	- **Logic, Theoret. Computer Science**	6
- **Technical Computer Science II** (Computer Systems, Computer Architectures)	8	- **Technical Computer Science II** (Computer Systems, Computer Architectures)	8
- **Mathematics III**	6	- **Mathematics III**	6
- **Area to Choose** (Coding + Modelling and Databases I plus 2 subjects, e.g. Operating Systems and Communication + Networks	16	- **Area to Choose** (Coding + Modelling and Databases I plus 2 subjects, e.g. Operating Systems and Communication + Networks	16
- **Mandatory Application Area to Choose** (# Process and Systems Engineering # Mechanical Engineering # Electrical Engineering)	16	- **Mandatory Application Area to Choose** (# Process and Systems Engineering # Mechanical Engineering # Electrical Engineering)	16
- **Software Training**	4	- **Software Training**	4
- **Proseminar**	2	- **Proseminar**	2
Sum	***90***	*Sum*	***90***
Advanced Studies (3 semesters)		*Advanced Studies (6 semesters)*	
- **Computer Science I** (3 subjects)	12	- **Computer Science I** (3 subjects)	12
- **Area to Choose in Computer Systems Engineering** (3 related subjects)	12	- **Area to Choose in Computer Science** (2 related subjects)	8
- **Mandatory Application Area to Choose** (# Process and Systems Engineering # Mechanical Engineering # Electrical Engineering)	12	- **Area to Choose in Computer Systems Engineering** (6 subjects)	24
- **Seminar**	2	- **Mandatory Appl. Area to Choose** (# Process and Systems Engineering # Mechanical Eng.: Construction # Mechanical Eng.: Production # Electrical Engineering)	24
- **Professional Practical Training**	20 weeks	- **Professional Practical Training**	20 weeks
- **Student Research Project**		- **Student Research Project**	
		- **Seminars**	4
		- **Laboratory Training**	5
		- **"Diplom" Thesis**	5 months
		- **"Diplom" Colloquium**	2
Sum	***38***	*Sum*	***79***

* HPWS = hours of effort per week of semester

Table 3: Excerpt of curricula of traditional courses of study in *Computer Systems Engineering* at the Otto-von-Guericke-University Magdeburg, Germany [19].

Transitions

Three kinds of transitions are allowed now: Students are allowed to continue a Bachelor program with a Master course of study and they are allowed to change the educational institutions within Europe. Ultimately, resuming a Master program's research in a universities PhD program is feasible, too. In lawful exceptional cases and with special identification of student's adequacy, even Bachelors may be permitted for admission to a PhD program. In contrast to the still centrally determined preconditions qualifying for Bachelor programs, the preconditions for admission to Master programs can be determined by the universities and universities of applied sciences by themselves.

Baccalaureate in Commercial Information Systems	HPWS*	"Diplom-Wirtschaftsinformatiker" ("Diplom" in Commercial Information Systems)	HPWS*
Basic Studies (4 semesters)		*Basic Studies (4 semesters)*	
- **Mathematics I and II**	12	- **Mathematics I and II**	12
- **Computer Science I** (Algorithms and Data Structures, Logic)	19	- **Computer Science I** (Algorithms and Data Structures, Logic)	19
- **Propaedeutics Business Studies / Economics** (Cost Accounting, National Accounts)	4 8	- **Propaedeutics Business Studies / Economics** (Cost Accounting, National Accounts)	4 8
- **Business Studies A** (Main Features of Business Studies, Cost Calculation)		- **Business Studies A** (Main Features of Business Studies, Cost Calculation)	
- **Statistics A** (Statistics I, Decision Theory)	10	- **Statistics A** (Statistics I, Decision Theory)	10
- **Area to Choose in Com. Science**	12	- **Area to Choose in Com. Science**	12
- **Economics A**	6	- **Economics A**	6
- **Area to Choose in Economics** (# Business Studies B (Financial Stmts.) # Business Studies C (Marketing, …)	8	- **Area to Choose in Economics** (# Business Studies B (Financ. Stmts.) # Business Studies C (Marketing, …)	8
- **Commercial Information Systems** (Introduction, Basics of Integrated Application Systems)	8	- **Commercial Information Systems** (Introduction, Basics of Integrated Application Systems)	8
- **Software Training**	4	- **Software Training**	4
- **Proseminar**	2	- **Proseminar**	2
Sum	***91***	*Sum*	***91***
Advanced Studies (3 semesters)		*Advanced Studies (6 semesters)*	
- **Computer Science III** (3 subjects)	14	- **Computer Science III** (4 subjects)	16
- **Commercial Information Systems II** (3 related subjects)	16	- **Commercial Information Systems II** (3 related subjects)	16
- **Advanced Studies in Comp. Science**	12	- **Business Studies I**	16
- **Seminar**	2	- **Advanced Studies in Business Studies II**	14
		- **Advanced Studies in Comp. Science**	12
		- **Seminar**	2
Sum	***44***	*Sum*	***76***

* HPWS = hours of effort per week of semester

Table 4: Excerpt of curricula of traditional courses of study in *Commercial Information Systems* at the Otto-von-Guericke-University Magdeburg, Germany [20].

4.2 Case Study: Status of Implementation of the Bologna-Process in Computer Science Education at the Otto-von-Guericke-University

The intention was to completely implement the Bologna-process in Germany by 2010, thereby removing the mixture of traditional "*Magister*" and "*Diplom*" courses of study and modern, European Bachelor and Master programs. However, the situation turns out to be reverse: Students matriculated at educational institutions of higher education are being permitted to complete the programs they started. In times of empty governmental cash boxes no double teaching resources for old and new programs are available, so that both are permanently mixed and taught by the same teaching staff [12].

As a good example for the status of implementation of the reformation process in Computer Science education in Germany, reference is again made to the case study involving the Otto-von-Guericke-University used in chapter three. The following Bachelor and Master programs in Computer Science have been filed or already approved by a special board organized by the Ministry of Education of the federal state Saxony-Anhalt: Computer Science (Bachelor and Master), Computational Visualistics (Bachelor and Master), Computer Systems Engineering (Bachelor and Master) and Commercial Information Technology (Bachelor and Master). From the full specifications of Bachelor and Master programs in Computer Science studies at the Otto-von-Guericke-University Magdeburg excerpts showing short specifications are presented in extracts beneath in Tables 5 for Bachelor and in Table 6 for Master programs.

Computer Science (Bachelor)	
Name of course of studies:	Computer Science (Bachelor)
Category of course of studies:	Full-time course of study
Academic grade:	Bachelor of Science (B.Sc.)
Volume/ Number of credits:	210 credits (seven semesters including one semester for professional practical training)
Short trait and credit point breakdown:	- Computer Science (113 credits) - Mathematics (26 credits) - Key competencies (26 credits) - Minor subject (15 credits) - Professional practical training (15 credits) - Bachelor-Thesis and Colloquium (12+3 credits)
Computational Visualistics (Bachelor)	
Name of course of studies:	Computational Visualistics (Bachelor)
Category of course of studies:	Full-time course of study
Academic grade:	Bachelor of Science (B.Sc.)
Volume/ Number of credits:	210 credits (seven semesters including one semester for professional practical training)
Short trait and credit point breakdown:	- Computer Science (88 credits) - Mathematics (26 credits) - Key competencies (26 credits) - General Visualistics (20 credits) - Application subject (20 credits) - Professional practical training (15 credits) - Bachelor-Thesis and Colloquium (12+3 credits)
Computer Systems Engineering (Bachelor)	
Name of course of studies:	Computer Systems Engineering (Bachelor)
Category of course of studies:	Full-time course of study
Academic grade:	Bachelor of Science (B.Sc.)
Volume/ Number of credits:	210 credits (seven semesters including one semester for professional practical training)
Short trait and credit point breakdown:	- Computer Science (68 credits) - Mathematics and Logic (26 credits) - Key competencies (26 credits) - Computer Science Advanced Studies (30 credits) - Application subject (30 credits) - Professional practical training (15 credits) - Bachelor-Thesis and Colloquium (12+3 credits)
Commercial Information Technology (Bachelor)	
Name of course of studies:	Commercial Information Technology (Bachelor)
Category of course of studies:	Full-time course of study
Academic grade:	Bachelor of Science (B.Sc.)
Volume/ Number of credits:	210 credits (seven semesters including one semester for professional practical training)
Short trait and credit point breakdown:	- Computer Science (48 credits) - Commercial Information Technology (40 credits) - Economy (44 credits) - Mathematics (22 credits) - Key competencies (26 credits) - Professional practical training (15 credits) - Bachelor-Thesis and Colloquium (12+3 credits)

Table 5: Excerpt of short specification for Bachelor programs in Computer Science studies at the Otto-von-Guericke-University Magdeburg, Germany [22].

Computer Science (Master)	
Name of course of studies:	Computer Science (Master)
Category of course of studies:	Full-time course of study
Academic grade:	Master of Science (M.Sc.)
Volume/ Number of credits:	90 credits (three semesters including one semester preparation of Master thesis)
Short trait and credit point breakdown:	- Computer Science A (18 credits) - Computer Science B (18 credits) - Computer Science C (12 credits) - Master-Thesis (30 credits)
Computational Visualistics (Master)	
Name of course of studies:	Computational Visualistics (Master)
Category of course of studies:	Full-time course of study
Academic grade:	Master of Science (M.Sc.)
Volume/ Number of credits:	90 credits (three semesters including one semester preparation of Master thesis)
Short trait and credit point breakdown:	- Computer Science (18 credits) - Computational Visualistics (18 credits) - Application subject (12 credits) - Key competencies / scientific team project (12 credits) - Master-Thesis (30 credits)
Computer Systems Engineering (Master)	
Name of course of studies:	Computer Systems Engineering (Master)
Category of course of studies:	Full-time course of study
Academic grade:	Master of Science (M.Sc.)
Volume/ Number of credits:	90 credits (three semesters including one semester preparation of Master thesis)
Short trait and credit point breakdown:	- Computer Science A (18 credits) - Computer Science B (18 credits) - Engineering Subject (12 credits) - Master-Thesis (30 credits)
Commercial Information Technology (Master)	
Name of course of studies:	Commercial Information Technology (Master)
Category of course of studies:	Full-time course of study
Academic grade:	Master of Science (M.Sc.)
Volume/ Number of credits:	90 credits (three semesters including one semester preparation of Master thesis)
Short trait and credit point breakdown:	- Computer Science (18 credits) - Commercial Information Technology (18 credits) - Economy (12 credits) - Master-Thesis (30 credits)

Table 6: Excerpt of short specification for Master programs in Computer Science studies at the Otto-von-Guericke-University Magdeburg, Germany [22].

5 Conclusion

The Bologna-process is generally seen as a step into the right direction towards a Europe being not only unified on paper by the charter, but in real-life as felt by its inhabitants. Because sophisticated and well-structured education of young people sets a cornerstone for a positive evolution on all areas, the part of higher education deserves special attention from planners of a unified Europe. Thus, with the 1999 declaration of Bologna 29 European Ministers of Education addressed a number of reformation issues for higher education to be implemented by the year 2010, and which are expected to facilitate mobility of students and teachers throughout the participating countries as well as facilitating lifelong learning. Since this development also affects higher education in Computer Science, this paper has used the example of the Federal Republic of Germany, described how history had shaped the format of higher education at the start of the process, and tried to mirror its evolution in recent years supported by respective normative references. Finally, the paper gave an overview of the latest developments in Computer Science studies according to the Bologna-process aligned with committing regulations for German higher education.

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