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Progress in Study Programs at CTU – Faculty of Electrical Engineering 16 Years after the Bologna Declaration

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Abstract

Main changes in study programs at the Czech Technical University in Prague (CTU) based on the Bologna declaration [1] were completed more than 10 years ago [2]. The bachelor and master degree studies were strictly separated, and new separate study plans had to be worked out. It brought both advantages and disadvantages, and later it resulted in further changes in the study programs. The paper aims to show how CTU, the Faculty of Electrical Engineering (CTU–FEE), has taken the advantage of the changes and how the disadvantages have been solved.

Keywords: Advantages, Bologna declaration, Disadvantages, Experience, Solution.

Introduction

The higher education institutions in the 47 partner countries are undergoing a demanding and at the same time very promising process of development. This process began in 1998 by the Sorbonne Declaration [3]. The Education Ministers of Germany, France, Italy and the United Kingdom announced their intention to establish structural compatibility between European institutions of higher education, remove existing obstacles to mobility and establish the basis for improved European cooperation between institutions of higher education.

Other European states responded positively to the initiative and on June 19, 1999, 30 European countries signed the so-called Bologna Declaration. Several Follow-up Conferences came after. The first took place in Prague on May 19, 2001 [4]. A further seven European states joined the Bologna Process at the second Follow-up Conference, which was held in Berlin on September 18 and 19, 2003 [5]. The third Follow-up Conference took place in Bergen (Norway) on May 19 and 20, 2005 [6], and the fourth in London on May 17 and 18, 2007 [7].

However, there are very large qualitative differences between the higher education systems and practices in different European countries, which will not be apparent in the essentially quantitative approach to harmonization basic to the Bologna process. For instance, as far as Germany (and also the Czech Republic) is concerned, it is likely that the recent changes in its higher education system, which will bring it closer to the British system, will have unwanted consequences that at least in part are wholly predictable on the basis of the very different historical developments in these two countries [8].

The application of the Bologna declaration caused a strict separation of the bachelor and master degree studies. It brought problems in some areas of education. It concerns e.g. in the medical education [9], [10] or teacher education [11]. Also in considering the Bologna Declaration and its implications for engineering education it is necessary to examine the historical evolution of engineering education in different countries. There were several basic models of engineering education in Europe – see [12]. To solve these problems, several workshops dedicated to this area were arranged, e.g. a workshop “The Bologna Declaration and Engineering Education in Ireland” [13], an impact assessment in Civill Engineering Education was discussed e.g. in [14], etc.

Experience Gained at CTU in Prague

Concerning engineering education, a separation of the bachelor and master degree studies caused the number of theoretical courses preceding technically oriented courses to rapidly decreased in a bachelor study, which consequently led to the changes in master study programs, as well. Additional courses in theoretical disciplines were included to compensate a low number of

theoretical courses in the bachelor period [15]. Last years have shown both advantages and disadvantages of this resolution.

Progressive termination of the former five-year master study programs have worsened the education of theoretically focused students who wanted to concentrate on R&D. A multi-year interval arising between basic theoretical courses in a bachelor study and special theoretical courses in a master study has brought about problems. On the other side, the unrestricted link between bachelor and master study stages facilitates the establishment of new multidisciplinary master programs, following up several different bachelor programs.

Four new study programs were open, based on the experience gained after the implementation of the Bologna declaration at the CTU–FEE. Three of them take advantage of the separation of both types of study, the fourth one reacts to the fact that the bachelor programs should prepare students both for practice and a following study, which is not optimal for good training, e.g., before the following doctoral study (PhD study). Two interdisciplinary master degree programs, one new joined bachelor program, and a special program designated especially for talented students, formally divided into two programs (bachelor and master), have been established in CTU-FEE in the several recent years.

CTU–FEE opened a new master degree program "Biomedical Engineering and Informatics" in the academic year 2011/2012 [16]. This program is based on the tradition of research and teaching in the field of biomedical engineering at FEE. In this area, the faculty has an international reputation in scientific research activities and a long tradition in collaboration with the medical workplaces, as well as medical device manufacturers.

The second interdisciplinary master program "Smart Buildings" [17] arose as a result of the cooperation of three faculties. It educates professionals having wider knowledge (but who are not be narrow specialists) in the design, realisation and control of smart buildings, which complies with the demand for such a kind of professionals in building industry. It includes a number of courses comprising the knowledge from electrical, civil and mechanical engineering necessary for smart building design and realisation.

Low efficiency in teaching the subjects in English (due to a small number of students in specialised programs) gave birth to a new joined bachelor program "Electrical Engineering and Computer Science"[18]. It consists of eighteen compulsory courses and fourteen partly optional courses, from which seven have to be selected in four specialisations.

While the programs mentioned above exploit the advantages of the Bologna process, the fourth one "Open Electronic Systems" [19] solves a drawback given by the termination of five-year master study programs mentioned above. In this case, two formally separate programs (bachelor and master) form one five-year long program designated especially for talented students. In fact, it should prepare the students for their following doctoral (PhD) study.

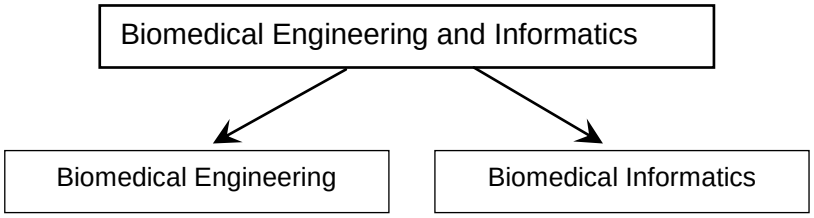
The structure and content of the new study programs mentioned above will be described in the following sections in more detail, including the first experience.

Master Degree Program in Biomedical Engineering

The program was designed on demand of great hospitals that use advanced instrumentation and need specialists in electronic instrumentation, signal processing and informatics with basic knowledge in medicine and corresponding areas. The aim of the program is to educate graduates in this attractive and promising interdisciplinary branch [16]. There are two specialisations in the program (see Figure 1).

The compulsory courses in the program (for both specialisations) integrate the basic medical education with proficiency in engineering and informatics focused on medical applications. The first part of the courses comprises Physiology and Anatomy, Medical Terminology, Medical Ethics, Organization of the Health Care System and Corresponding Legislation. The lectures in these courses are given by the teachers from Charles University, Faculty of Medicine. The second engineering part focusing on Signal Analysis, Informatics, Statistics, Modelling and Simulation and Image Processing is instructed by the experts from FEE.

Figure 1. *Specialisations in the Program: Biomedical Engineering and Informatics*



There are twelve following compulsory courses in both specializations. In the case of Biomedical Engineering, there are, for example, the following courses: Biological Signals, Medical Instrumentation and Devices, Medical Imaging Systems, Biomedical Sensors and Construction of Medical Systems, etc. Similarly, in the case of Biomedical Informatics it concerns, e.g., the following ones: Advanced Algorithms, Bioinformatics, Machine Learning and Data Analysis, Assistive Technologies, Patient Supervision Systems, etc.

In this program, about twenty students graduate every year. The demand for these specialists in great hospitals exceeds this number at the present time. This program is offered also in English.

Master Degree Program in Smart Buildings

Optimising operational costs, smart buildings guarantee optimal in-door environment in homes, as well as in office and industrial buildings. It is reached thanks to the application of cutting edge knowledge of modern materials and construction elements, air-conditioning and control systems, mechanical, electrical and electronic equipment, etc.

Study program "Smart Buildings" [17] educates future professionals in the design, realisation and control of smart buildings. The students get a wide overview on all areas mentioned above; they are trained to be able to coordinate and integrate the expertise of different specialists. After graduating, they can find their jobs in ateliers, working on conceptual design of contemporary buildings, or in construction firms in leading positions dealing with general concepts of the construction, maintenance and operation of smart buildings, etc.

The study program was set up in cooperation with leading potential employers. It is designed so that all students gain necessary overview on the above mentioned areas on a master´s degree level in the compulsory courses. Five of these courses belong to the area of civil engineering, four of them concern mechanical engineering and three relate to electrical engineering. It concerns, e.g., the following courses: Building Structures, Energy and Ecological Systems, Lighting and Acoustics, Air-Conditioning Systems, Sensor Networks, Power Networks in Buildings, etc.

The second part is composed of elective courses, from which seven, at minimum, is necessary to choose. Their aim is to provide the students with the knowledge complementary to the expertise gained in their previous bachelor study, e.g., to complete the proficiency of bachelors in civil engineering with electrical and mechanical engineering knowledge, etc. The choice of these courses is limited, i.e., the undergraduates in civil engineering cannot choose elective courses form the same area, etc.

In each field about eight courses are offered. In civil engineering it concerns, e.g., the following ones: Integrated Building Design, Building Energy Performance, Modelling Energetic Systems of Building, Fire Protection of Buildings, etc. Similarly, in mechanical engineering, the following courses are offered, e.g., Fundamentals of Ventilation, Fundamentals of Heating, Alternative Energy Sources, Cooling Systems, etc. In electrical engineering: Measurement in Buildings, System Modelling and Simulation, Data Acquisition Systems, Electromagnetic Compatibility, etc.

Each year about 30-40 students graduate in this programme. Many of them complete their diploma theses outside their home faculties, either in the firms or at the University Centre for Energy Efficient Buildings of CTU [20]. The majority of them find their future jobs without any problem, particularly in big construction companies, designing centres, etc. This program is available only in Czech language.

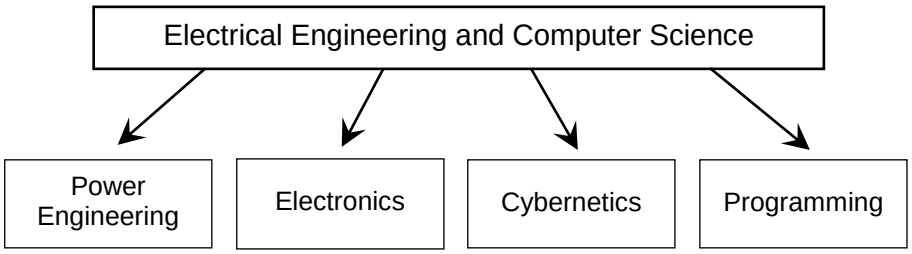
Joined Bachelor Program in Electrical Engineering and Computer Science

The fact that in independent study programmes ("Electrical and Power Engineering and Management", "Electronics and Communications", "Cybernetics and Robotics"), runs in English, a relatively small number of bachelor students were enrolled, led to forming a new joined bachelor program "Electrical Engineering and Computer Science" (EECS) [18]. EECS graduates get wide and very versatile theoretical knowledge in fundamental engineering disciplines, e.g., discrete and continuous mathematics, physics, algorithms, and programming.

The overall aim of the EECS study program is to enable students to select from a variety of career options. Graduates become proficient in electrical engineering, power engineering with extended knowledge of economics and management, software and embedded systems development, computer science, and information technologies. High flexibility of an EECS program allows students to configure their own study profile. EECS graduates will be able to start their career in industry, but also they will be well prepared to continue in their master's studies.

Compulsory courses cover Mathematics (Calculus, Linear Algebra, Discrete Mathematics, Graph Theory, Probability and Statistics, as well as mathematical applications and practical implications for programming, constructing and analysing algorithms), Physics, and fundamental knowledge concerning electrical engineering and computer science (Electrical Circuits, Electronic Elements, Microcontrollers, and Programming Essentials). The program offers four specialisations (see Figure 2) which are determined by a choice of optional courses.

Figure 2. *Specialisations in the Program: Electrical Engineering and Computer Science*



Power Engineering

In this specialisation, students learn how to manage electrical power systems, how to achieve power transmission stability, frequency, grounding and dimensioning electrical power, all kinds of electrical systems and power sources. The following courses belong to this specialisation: Power Engineering, Materials for Power Engineering, Electrical Apparatus and Drives, etc.

Electronics

Students learn the fundamentals of electromagnetic field theory, principles of electronic devices operation, properties and types of materials and technologies for electrical engineering. The relevant knowledge is obtained in the following courses: Electromagnetic Field Theory, Signal Theory, Computer and Communication Networks, Electronic Devices, etc.

Cybernetics

Students get familiarized with automatic control. A graduate from the program will be able to control different devices by programming, including reading data, analysing it thoroughly, and designing control or decision-making algorithms. The following courses can help them to manage it without any difficulties: Automatic Control, Patter Recognition and Machine Learning, Theory of Signal Processing.

Programming

Students focusing on computer science learn one high-level and one low-level programming language and are trained in creating algorithms and problem solving by understanding computer networks, as well as, computer systems and structures.

In addition, other courses, which belong to several specialisations, are offered, e.g., Sensors and Measurement (for all specialisation except Programming) and Programming language C. This programme is taught in English only.

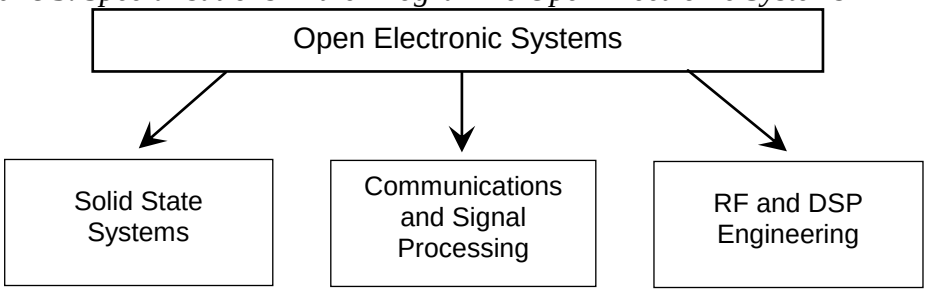
Open Electronic Systems

Before the implementation of the Bologna declaration, the former five-year master programs provided talented students with an appropriate training to be able to continue their studies on the doctoral level (PhD study). Presently, the interval of several years between basic theoretical courses on the bachelor level and special theoretical courses on the master level brings about problems. For this reason, the program "Open Electronic Systems" [19] was created to solve this drawback. It is designed to bridge the gap and prepare the students for their following doctoral (PhD) studies. It consists of two (formally separated) programs – bachelor and master – that are strongly interconnected.

This program covers the areas of state-of-the-art electronics, communications, wireless and electronic systems, etc. It is built on an idea of "the pyramid of education", where the lower stage has to be more sturdy and wider than the upper stage. On the bachelor level, it includes both the compulsory courses of mathematics and physics background, and the courses that provide a general basis for the following study of electronic systems. The

follow-up master program based on this basic knowledge enables wide eligibility of specialisations. The program offers three basic specialisations (see Figure 3).

Figure 3. *Specialisations in the Programme Open Electronic Systems*



There are nine compulsory courses in each specialisation and the students have to sign in some more courses from other specialisations or programmes and take them as optional.

All teaching materials are in English. A mix of Czech and foreign students enables to gain necessary international compatibility. The teaching language is English, in case the lecturer is a foreigner, or if at least one student cannot speak Czech.

Conclusions

The experience in the implementation of the Bologna declaration to the study has shown that, on the one side, it enables to create interdisciplinary master study programs, but, on the other side, its rigorous interpretation does not enable the existence of five-year master programs in most of the branches. However, there can be a chance how to solve it. CTU in Prague may be supposed to establish some five-year programs for excellent students similarly as in the case of the Open Electronic Systems and also interdisciplinary programs on a master level which follow up several independent bachelor programs. It might concern, e.g., aircraft or automotive technology that may join electrical, mechanical and transportation engineering. These master programs, meeting the requirements of industry, are now prepared at CTU for the implementation.

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