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CURRICULA DEVELOPMENT IN CIVIL AND STRUCTURAL ENGINEERING EDUCATION

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German civil and structural engineering education is experiencing major changes for the last 15 years mainly based on the Bologna Treaty. This research focuses on the question on how the curricula in civil and structural engineering programs have changed over the last 15 to 20 years, especially due to a) the requirements of the Bologna Process, and b) to the influence of non-academic organizations such as. professional associations. The conclusion is that these curricula have been greatly modified. Study programs leading to a first-cycle degree were shortened and interdisciplinary courses were included. Because of the increasing importance of interdisciplinary courses, and of general subjects such as presentation techniques, foreign languages, and career guidance, the time devoted to specific technical subjects and internships had to be reduced. This raises concerns within the industry about whether students bachelor graduates will be able to work professionally.

Keywords: European higher education area, Bachelor and master programs, Quality, Bologna Treaty, Bologna Process, Interdisciplinary engineering programs.

1 15 YEARS OF THE BOLOGNA PROCESS

In 1999 in the Italian city of Bologna, 29 European countries committed themselves to create a common European Higher Education Area, resulting in the Bologna Declaration. The Bologna Process (Hochschulrektorenkonferenz 2004) caused the most comprehensive change in the German Higher Education System for 200 years. Numerous reforms were set in motion with the aim to make European Higher Education more coherent, competitive, and attractive for European students as well as academics and researchers from non-EU-countries. In the meanwhile, some follow-up conferences were held resulting in further *communiqués*, such as the *Bergen Communiqué* or the *London Communiqué*. The Bologna Process today includes no fewer than 47 participating countries.

As one consequence, German study programs were replaced by new bachelor and master programs, and requirements resulting from the Bologna Declaration must be obeyed in a curriculum's changing processes. Furthermore, non-university organizations that are not a part of the academic society, such as accreditation agencies, professional associations, and quality managers, have had increasing influence on curriculum design and development.

What the European Ministers for Higher Education and Research in Bologna agreed to on paper was causing considerable problems for universities throughout Europe. By 2010 German universities were required to put into effect policies agreed to in the

Bologna Declaration. Currently, most of the required modifications in study structures at German universities are completed.

2 CURRICULUM DEVELOPMENT

2.1 Methodology of Investigation

This paper compares different civil and structural engineering curricula of four German universities and universities of applied sciences over the last 20 years. The study plans of the former *Diplom-Ingenieur* programs and new bachelor programs of RWTH Aachen (RWTH Aachen 1998, RWTH Aachen 2004, RWTH Aachen 2009, RWTH Aachen 2012), TU Dresden (TU Dresden 1999, TU Dresden 2008, TU Dresden 2009, TU Dresden 2012), TU Braunschweig (TU Braunschweig 1999, TU Braunschweig 2001, TU Braunschweig 2014) and HTWK Leipzig (HTWK Leipzig 1994, HTWK Leipzig 2001, HTWK Leipzig 2007, HTWK Leipzig 2014) were evaluated.

2.2 Requirements from the Bologna Process

When comparing the courses of the various curriculums, there were clearly numerous changes resulting mainly from the requirements of the Bologna Process. For example, the former German civil engineering education leading to the degree of *Diplom-Ingenieur* was replaced by bachelor and master programs. In Germany, when developing or changing a study program's curriculum, the dean for study affairs and elected faculty councils must be involved. In these councils, representatives of all faculty member groups, professors, scientific and administrative staff, and students are involved. The faculty councils are mandated to plan or change a course of study in accordance with legal requirements, under the fundamental right of free teaching and research of all lecturers in the program.

The former *Diplom-Ingenieur* programs at German universities had a regular period of study of 10 semesters, whereas at universities of applied sciences they had 8 semesters. As a consequence of the Bologna Process, more than 88% of the former courses of studies at German universities were replaced by bachelor and master courses. Today, 7,685 bachelor programs and 7,689 master programs are offered by universities in Germany (Hochschulrektorenkonferenz 2014). Their curricula had to be structured in modules according to the guidelines of the Bologna Declaration. Modularization means here the combination of lectures and seminars with similar program contents in thematic units. Furthermore, credit points according to the European Credit Transfer and Accumulation System (ECTS) should be awarded for each successfully-completed module, but not more than 60 credit points per year.

The requirement of 60 credit points per academic year assumes that 1500-1800 hours are available in this period of time. However, in the absence of homogeneity concerning the length of study times and semesters at European universities, this does not apply to all European countries. For example, in Great Britain, one ECTS point is defined as 20 students' working hours, while in Norway working hours are not defined at all (European Commission 2009). These definitions essentially prove that "ECTS points" are not standard in the European Higher Education Area.

The implementation of bachelor and master degrees should help to improve the comparison of study programs in Europe. However, even in Germany the programs are

not comparable. For example, German universities offer various bachelor programs in which students may be awarded 180, 210, or even 240 ETCS credit points, depending on the regular period of study. This must be less than four years, but at least three years for an undergraduate program.

Furthermore, problems with students' mobility have not improved, because there is no time for studying abroad in a three-year bachelor program (Mücke 2008), particularly in the labor-intensive engineering programs. In spite of the efforts in creating a common Higher Education Area, the transfer of collected credit points between domestic and foreign universities has not become easier. Moreover, bachelor degrees with a regular period of study of less than 8 semesters are often not accepted at foreign universities for entrance to a master program (Schlicht and Warnecke 2008). Usually it means a longer period of study for students who are planning to go abroad.

2.3 Employability

One of the difficulties in implementing the new study structures was shortening *Diplom-Ingenieur* programs leading to a first-cycle degree from 4-5 years to 3-3.5 years while ensuring graduates' professional qualifications. Further, in addition to scientific basics and classical civil engineering subjects, interdisciplinary courses and general subjects had to be included in the bachelor curriculums. Time devoted to the specific technical subjects had to be reduced. So-called "soft skills", such as professional orientation, scientific work/presentation, multidisciplinary compulsory optional modules, foreign languages and *Studium Generale* were incorporated into the curricula.

To ensure first-cycle degree graduates were able to work as a fully-qualified engineer, some German universities have shortened the practical training, for example from 13 weeks to 6 in the Bachelor Program Civil Engineering of the Faculty of Civil Engineering at Leipzig University of Applied Sciences. Other universities try to overburden their study programs to avoid disadvantages for their graduates on the labor market (Quapp and Holschemacher 2010). However, despite these efforts, bachelor program students still are concerned about being second-class graduates compared with graduates of the former *Diplom-Ingenieur*'s programs. Seventy-three percent of the bachelor students have serious doubts concerning their degree's acceptance among the employers, and do not feel sufficiently prepared for the labor market (Institut für Demoskopie Allensbach 2014). As consequence, 61% plan to join a master program after being awarded a bachelor's degree (Institut für Demoskopie Allensbach 2014). Moreover, the students' concerns are well-founded about whether a bachelor with 6 semesters of study is able to work professionally as an engineer in the existing job market, fulfilling the same real job requirements as an *Diplom-Ingenieur*.

2.4 Influence of Non-academic Organizations

This section addresses the question about how much influence non-university organizations have on academic issues, such as creating engineering curricula. According to German Law, universities and in particular the lecturers are responsible for the course contents of degree programs. As a consequence of Article 5.3 Sentence 1

of the Basic Law of the Federal Republic of Germany, the Freedom of Science allows professors to define content and method of their courses, especially topics, and format such as lectures, seminars, practical and non-practical exercises, structure as well as duration (Fehling 2012).

Often there is a conflict between the Freedom of Science and the methods of study programs' quality assurance, which is mandatory in Germany. In former times, study programs were controlled by governmental framework studies and examination regulations for each field of study. Now, accreditation of study programs by private accreditation agencies is used as one pillar of universities' quality management. During this process, non-academic organizations such as accreditation agencies, the Standing Conference of the Ministers of Education and Cultural Affairs of the Federal States in the Federal Republic of Germany, chambers, and professional associations are able to influence the development of study programs in many different ways.

Accreditation agencies are private non-profit organizations that are accredited by the German Accreditation Council of the Foundation for the Accreditation of Study Programs. During the accreditation process, accreditation agencies verify compliance of the study programs with the recommendations and requirements from the Standing Conference of the Ministers of Education and Cultural Affairs of the Federal States in the Federal Republic of Germany, chambers, and professional organizations.

Moreover, the accreditation agencies give advice concerning the curriculum's content. So, the guidelines of one of the leading accreditation agencies for engineering programs, mathematics, informatics and sciences demands special teaching contents and learning outcomes (ASIIN 2012). Another non-academic organization requires a special percentage of course contents in a bachelor program, e.g., at least 30 credit points for mathematic and scientific basics, 21 credit points for subject-specific basics, and 9 credit points in interdisciplinary courses as well as general subjects etc. (Akkreditierungsverbund für Studiengänge des Bauwesens e.V. 2010).

If the study programs do not meet the requirements set by the aforementioned non-academic organizations, the accreditation can be rejected. Consequently, universities are forced to subordinate and observe the standards given by these extramural associations to avoid losing accreditation.

Of course it is important to create curricula close to the needs and requirements of the industry, but a certification of the university education's quality by private non-profit accreditation agencies is not the right method. Non-academic, extramural institutions should not have such a significant influence on civil engineering education. It is dangerous to gear too strongly to short-term industry needs, which in the longer term could cause a deterioration in education quality. For this reason, higher education for future engineers is a key matter of the universities and the previous system must be continued.

3 CONCLUSION

The Bologna Process has had an enormous influence on civil and structural engineering education curricula within the last 20 years. One argument for the modification, beside the intention to improve graduates' employability on the ever-changing global workplace, was the implementation of the obligations of the Bologna Process. However, because of the increasing importance of both interdisciplinary courses and

general subjects, such as presentation techniques, foreign languages and career guidance, the time devoted to specific technical subjects and internships was reduced. That results in a lower credibility within the industry towards bachelor degree graduates regarding the ability to work professionally, and the need to invest additional years in master degree programs.

Moreover, German universities have been losing their influence over academic education contents, and have been becoming a servant of quality-assurance managers and professional associations. It will soon become clearer whether the influence of non-academic organizations improves the civil and structural engineering education or not. The result of the development must be a modification of the requirements based on the Bologna Process.

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