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Keynote lecture I

The Bologna Process and the Civil Engineering Education Perspectives in Europe

by

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Summary

1. The Challenges for Civil Engineering

The engineering education and training systems have been under changes in the last few years. The main reasons that have caused this turmoil in Europe are the movement towards the harmonization of degrees, created by the Bologna process, the need for continuing professional development, the tendency for increased mobility of engineers and the lack of accepted global quality assurance of the education and training. So these facts have created throughout the last decade several challenges to engineering education and to engineering profession [1].

The next future in the engineering area will have to deal with various challenges like changes in the curriculum, adaptations of teaching/learning methods, implementation of systems directed recognition of engineering qualifications (academic and professional), development of global accreditation schemes, provision for continuing professional development and valuing informal acquisition of competencies and knowledge [2].

2. The Reasons for Change

2.1 Bologna Process

The harmonization of higher education degrees in Europe was initiated by the Sorbonne declaration of May 2000 signed by the four biggest countries of the European Union: France, Germany, United Kingdom and Italy. The respective ministers of education agreed to harmonize their higher education systems to have only three compatible degrees. The first one should be a short one of three to four years, followed by a second that would award a master and a third one that would give the title of doctor. One year later, twenty-five other countries agreed with the four previous ones to sign the Bologna declaration that aims at converging reforms towards a coherent, compatible and competitive European higher education area [3].

The Sorbonne Declaration aimed for the harmonisation of qualifications in order to make them readable and facilitate their recognition both within Europe and world-wide. The Bologna declaration called in a rather clear and operational way for the introduction of an undergraduate-postgraduate articulation of qualifications and for

credit systems compatible within Europe (European Credit Transfer System). The declaration also called for the promotion of European co-operation in quality assurance with a view to developing comparable criteria and methodologies [4]. The transcript of the joint communication of SEFI and CESAER is made in annex of this paper. It was distributed throughout the engineering community and especially in the educational sector. The text illustrates the recent preoccupations with the implementation of the Bologna process in the engineering area.

2.2 Quality Assurance

The existing developments in the signatories of the Bologna declaration towards reforming the engineering degree systems have been very diverse. Some countries have introduced profound reforms and others have not done practically any changes. The direct consequence among the engineering academic community is the awareness that the curricula and programs may be subject to doubts and uncertainties about the respective suitability for the engineering profession and for the competition in the European space. This has opened the path for some form of quality assurance in the engineering area [2].

Another aspect that has imposed debates about the quality of the engineering programs has been the changes occurred in the paradigm of teaching versus learning. The engineering programs have adopted a system based in the outputs assessment of the engineering graduates like competences and skills [5]. Since these are new in the assessment of the engineering curricula the engineering professionals and academics have been debating and implementing original forms of quality evaluation of the engineering programs suited for the curriculum development systems based on learning outcomes.

2.3 Globalization

In Europe, as well as towards the rest of the world, the modern engineer encounters problems when it comes to mobility and employability. When it comes to mobility, one can talk about it from the view of the prospective engineer, of the current engineer and of the prospective employer. For the current engineer it is a matter of the very build-up of the exact curriculum. The aim of these engineering courses is to be flexible about parts of the study programmes achieved at other higher education institutions and to transfer those between curricula. The active engineer wants to have the chance to look for other job opportunities in other countries. Also the professional engineering organizations and employers need to recognize the qualifications and competencies from engineers coming from other countries.

There is a clear shortage of engineers in the European Union and in other developed regions of the world. The technology requirements and the demographic trends have created a significant shortage of engineering graduates. On the other hand, in other parts of the world, engineering is still an attractive career and without shortage of candidates. Arising from this asymmetry between demand and offer two things will happen in the near future. One is the migration of skilled workers, like engineers, with the corresponding problems of recognition of qualifications. In fact, the World Trade

Organization is currently looking for a regulation of the engineering qualifications at the world level. The second effect will be the outsourcing of engineering done at continental level. That is already happening with some airline companies that perform their engineering maintenance in other continents. Global engineering is a trend with strong impact in the profession future.

2.4 Professional Development

The developments in the engineering profession and activities have created the need for suitable training programs compatible with the needs of the professional development. This has created a series of diverse providers of continuing education and of types of courses. This diversity has implied a difficulty in establishing standards and quality assurance mechanisms. These types of engineering programs represent high investments for companies and for engineers. All the above reasons have led to need for recognition of work done or knowledge acquired by the participants in the continuing education programs.

3. Questions for Civil Engineering Education

3.1 Initial Education

The goal of initial education of engineers has been changing in the last years due to the factors cited above. The modern courses have a tendency to adopt a philosophy of ensuring that the graduating engineer will have some acquired competences and skills at graduation. These are defined by a synthesis of opinions from academics, professionals and employers. Traditionally the engineering courses were based on the content and contact hours. Currently they are defined by the learning objectives and by the learner workload. This is a shift of paradigm and leads to major changes in the form and content of courses.

There are recent studies that show the type of competences and skills required for an engineer to work as a professional. For instance from the point of view of professionals some organizations require that the educational outcomes include ability to: apply knowledge of mathematics, science and engineering; design and conduct experiments; design a system, component or process to meet desired needs; function in multidisciplinary teams; identify, formulate and solve engineering problems; understand professional and ethical responsibility; communicate effectively; understand the impact of engineering solutions in a global and societal context; recognize the need and engage in lifelong learning; have a knowledge of contemporary issues; use techniques, skills and modern engineering tools necessary for engineering practice. In terms of contents it is required by academics that engineers have a combination of mathematics and basic sciences of about one fourth of the workload, a set of disciplines of engineering sciences that establish the bridge to engineering design of about another fourth and a group of engineering design activities related with the specific filed of study. It is desirable that students have a complement of general education courses. Employers have different, but somehow similar, interests in the learning outcomes of the courses like ability to solve problems, self-sufficiency,

foreign language skills, capacity to work in teams, critical thinking, practical experience, creativity, etc.. It is the result of the amalgam of these expectations that the profiles of engineering programs for initial education will be defined.

3.2 Attractiveness of Engineering Profession

It is noted that there are reduced numbers of applicants in the engineering disciplines. This is an issue that is critical and must be solved together by universities and industry. There is a decrease of population that has been affecting the enrolment but another factor has been a lack of interest in the engineering profession by society in general. There is a devaluation of the social benefits of this profession with a corresponding decrease in material compensation. This has diminished the image of engineers in the eyes of prospective engineering students. Efforts have to be made showing the importance of the engineering activities to the public in general, there should be a dissemination of engineering profiles among high school students and there should be more investment in salaries for engineers.

3.3 Life Long Learning (LLL)

The issue of providing continuing professional development is critical for engineers [6]. It is an area where the obsolescence of knowledge is intense and the tendency is to have more demands for training courses. The current offer is made by professional organizations, private providers, universities and corporations. These actions take several formats like postgraduate studies, weekend seminars, short courses, in house training, online studies and self learning activities. In certain cases the requirements for these lifelong learning activities are voluntary, others are mandatory and some are recommended. Corporations and professional bodies have a large importance in the provision of LLL activities in the areas of promotion and provision. The LLL activities are not mandatory in most countries and it is done on a random basis without the benefit of more abridging strategies. It is certainly a factor of competitiveness and should be considered as a component of the engineering profession with clear frameworks.

3.4 Quality - Accreditation and Recognition

It is clear that there are great differences between the European countries when it comes to determining and assuring quality of higher education. In some countries accreditation is already in place by means of departmental order, nationally recognised agencies or others. Facing these differences it is necessary to find the minimum common standard. Probably the starting point will be to trust national quality assurance systems [7]. It is not the aim of the international system to assure the fulfilling of the goals set by the higher education institution.

It is generally agreed on that a bottom-up approach is the one and only way to establish recognition of qualifications on an international level. In order to establish such an approach it is required to find the minimum standards in common and thus find the common qualification attributes desired. The main issue big about the outputs assessment is to find an accurate way to evaluate the criteria. The proposed approach focuses on the outcome of the educational process and not on its inputs, which are

more tangible and measurable. Accreditation of the courses has therefore become an inevitable activity for the academic institutions and for the engineering professional organizations. The issues considered essential are the protection of engineering profession, the mobility and transparency, the compatibility and improvement. A good example is the project EUR-ACE (European Accredited Engineer) that congregates most European organization related with engineering education or with professional organizations [8].

Accreditation of engineering activities have been analysed considering the classical degrees like bachelor, master or doctorate. The question of continuing professional development activities has been recently addressed due to the increasing importance of the lifelong learning in engineering. These activities become more difficult to recognize when taking the format of distance learning or of e-learning. A good example is the recognition of informal learning that may attract individuals to continue their studies in engineering [9]. This could contribute to enlarge the number of qualified elements in engineering and could help increasing the level of qualifications of the sector.

3.5 New Engineers - Accreditation of Informal and Prior Learning (AIPL)

This is a relatively new area where experiential learning can be credited towards a qualification. AIPL seeks to give credit for all learning by placing it within a recognised accreditation framework. It involves the identification of learning wherever and whenever it takes place, selection of that learning which is relevant to a desired outcome or progression route, demonstration of the validity of and appropriateness of that learning, matching learning outcomes to those stated within a chosen accreditation or progression framework, assessment of evidence against predetermined criteria to ensure the validity of the claimed competence and accreditation within an appropriate accreditation framework.

The relevant methodologies proposed for accreditation of AIPL are based on performance evidence and knowledge evidence. These evidences are connected with credit units that can quantify the embedment in a framework system enabling a formal partial or total recognition within a qualification framework. This qualification can lead to a degree or to a level of professional recognition. The board in charge of the analysis of the historical evidence and of other proofs of learning should look into authenticity, directness, breadth and currency. The approaches based on the workload and on competency-based systems require qualifications to have clear learning outcomes, levels and progression built into them. The learning outcomes act as the basis for the assessment of AIPL and any subsequent award of credits. Different methods exist for this accreditation process including the use of accreditation boards, portfolio presentation or just taking examinations.

4. Conclusions

The perspectives for Civil Engineering in Europe are challenging and promising.

The focus recently being made on the Bologna process just postpones other aspects that are probably more significant than those directly related with the Bologna process. It is a fact, according to the survey of the implementation of the Bologna process made by SEFI [10], that other subjects related with engineering education and profession have been included in the discussion. Bologna has the merit of promoting change and, therefore, giving opportunity for other improvements. The system of three degrees has been generally implemented, the ECTS is active on most universities, some countries and universities have adopted the diploma supplement. It is a process that will be generally implemented with several degrees of accomplishments.

There are issues that should be discussed besides those stated in detail previously that arise from the Bologna process and from the Bergen communiqué issued by the ministers of education. The question of evaluating the European credits, the financing of the higher education, the structural reforms of the quality and accreditation systems, the transformation of PhD studies into a profession, the attractiveness for foreign students, the qualification of the active engineers are probably the questions without answers for Civil Engineers. These are intensively related with the characteristics of the profile of this profession with relevance to the responsibilities assumed in civil, social and legal terms. It is necessary more debates and decisions that may, to a certain extent, be different from other engineering areas.

5. References

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ANNEX – Transcript

Communication CESAER/SEFI

"Engineering Education and Research and the Bologna Process –
On the Road to Bergen 2005"

Introduction

The Bologna process was initiated by politicians and signed by the ministers of European countries. The process aims at the harmonization of the structure of university education in Europe in order to facilitate mobility. A meeting of EUA (European University Association) was convened in Salamanca in 2001, which provided a forum for a discussion of the central issues of the Bologna process on a broad basis. The results obtained by several working groups were presented to the meeting of the ministers of education in Prague in 2001. The same procedure was used for the meeting in Berlin in 2003 and the EUA prepared the input at a meeting in Graz. The next monitoring of the ministers will take place in Bergen in 2005 and the universities are planning to prepare their statements at a meeting in Glasgow.

The Bologna process brings about specific problems in the field of studies of science and engineering. Therefore CESAER (Conference of European Schools for Advanced Engineering Education and Research) and SEFI (Societé Européenne pour la Formation des Ingénieurs) tried to develop a common view on the most important issues of the Bologna process. This was done prior to the Salamanca meeting, and for the Graz meeting a position paper was formulated in a workshop in Helsinki, in February 2003, which was open to the whole engineering community. In order to be prepared for the next meetings in Glasgow and Bergen the two societies convened a seminar on the Bologna process, which took place on June 4, 2004 in Madrid. This seminar was organized in five working groups on selected topics of the Bologna process. The aim was to disseminate the results in the engineering world in order to trigger off a broad discussion and to formulate a position paper of the two societies. This position paper reflects the conclusions of the Madrid seminar.

PhD in Engineering

1.1. PhD activities of doctoral candidates are the main source of innovation and new knowledge through research in the engineering sector. They also play an important role in the relationship between academia and industry. This level of training has a large diversity of format and content among universities. This variety should be maintained to ensure future development of research programmes. Nevertheless, primary emphasis should be given to the research work of candidates in all PhD programmes.

1.2. Any form of uniform requirements is likely to be counterproductive. However, some institutional norms concerning the quality management of doctoral programmes may enhance the organization of these programmes. Such norms should include the duration of the studies –normally 3 to 5 years of research-, its scope, additional education required and a schedule.

1.3. The outcome of the doctoral cycle should be PhD graduates who are capable of creating technological innovation, developing new disciplines and building bridges between the world of academic research and the world of innovations in business, industries and government. The PhD thesis should contain original research and should be prepared in close cooperation between candidate and adviser.

1.4. Each university should be responsible for the selection of its own PhD candidates. Universities could offer joint degrees to face the complexity of doctoral programmes. The universities can also cooperate as networks at European level. Association with industrial programmes is also a possibility to ensure development of engineering scientists.

1.5. Doctoral candidates should be considered as researchers and should be recognized as professionals who make a key contribution to the creation of new knowledge through research.

Bachelor/Master Studies in Science and Engineering

2.1. The 3+2 model has become a standard reference in engineering. This should not exclude other possible paths towards the second-level degree, such as an integrated 5 years curriculum or a 4+2 scheme or a 4+1 model.

2.2. Engineering needs at least two types of first-level degrees, each with clearly-defined aims and objectives. First cycle degrees should be a gateway to a wide choice of second cycle programmes. The receiving institutions have the freedom to define criteria and procedures for the selection of students for the second level degree courses.

2.3. Obstacles for mobility at the end of the two cycles within the European Union should be eliminated at the academic and at the professional levels. The competition between universities created by the two cycles is a positive factor and should be welcomed.

2.4. Mutual and unconditional recognition of the learning outcomes of study programmes between two or more institutes might have a more profound impact on mobility of students than the simple accumulation of ECTS credits. Some examples of this recognition already exist on the national and international level.

Double and Joint Degree Programs

3.1. Trans-national recognition of engineering degrees, academically and

professionally, is a primary goal within the context of the Bologna process. Double and joint degrees seem particularly appropriate to facilitate this recognition.
3.2. There is a need for the identification and compliance requirements of legal and of financial procedures to make these joint degrees possible. The importance of the diploma supplement to promote this type of degree is high and may be indispensable for the implementation.

Further Development of ECTS
4.1. The disciplines that compose the engineering degrees should be defined primarily in terms of learning outcomes. This definition tries to reflect the paradigm change from input (workload) to output (competences).
4.2. The ECTS credits are primarily a workload measure and a planning tool. The number of ECTS credits awarded for achieved learning outcomes depends on many factors, such as programme design, teaching methods, student abilities and motivation. The credit system needs further development to include other type of indicators.
4.3. In Engineering the whole set of competences acquired in an integrated programme does not represent the mere addition of the ECTS credits of the modules. The outcome is a result of an integrated education and care should be taken to ensure a proper curriculum. Also, the use of the ECTS in Engineering cannot be used to standardize the degrees in Europe.
4.4. ECTS credits should not necessarily be applied to the PhD since an essentially curriculum based PhD-programme cannot fulfil requirements concerning the personal independence, the research experience and alike.

Quality Management – Accreditation – Autonomy
5.1. In Engineering education programmes the quality assessment and accreditation procedures must be based on learning outcomes. These outcomes should be classified in three areas: competences, skills and knowledge. To make the process transparent there is a need for the operational definitions of quality criteria for these learning outcomes.
5.2. It is recommended that the quality management and quality assurance systems are as decentralized as possible. A primary concern is that these systems do not become an extra burden for the academic staff and for the administration.
5.3. There is a need to increase the co-operation and the dialogue between academic recognition actors and professional accreditation organizations. Since academic recognition and professional accreditation are two different issues there must be a coordination to simplify procedures.
5.4. The academic recognition in Engineering of the programmes in Europe must have some characteristic features in common. Some of these elements may be a self-evaluation procedure, quality guidelines defined by an external body and an academic recognition body from the engineering community.
5.5. It is recommended that a European organization for academic recognition and professional accreditation be established. The tasks of this organization are to develop a framework of European guidelines and to co-operate, as well as to complement, the national bodies.

The role of CESAER and SEFI

CESAER - The Conference of European Schools for Advanced Engineering Education and Research – founded in 1991, is a multinational association of some 55 leading European universities and schools specialised in academic engineering education and research. These institutions exert a powerful influence on technological growth and workforce development, and ultimately on the viability of the European economy.

SEFI - The European Society for Engineering Education -, founded in 1973, is an international non-profit organization linking together 480 members amongst which ones 250 European universities and institutions of higher engineering education (38 countries). Through its network and its numerous activities and services offered to its members, SEFI has a serious expertise relating to the situation of higher engineering education in Europe. SEFI contributes to the development and improvement of HEE, to the improvement of exchanges between teachers, researchers and students, and of industry with the academics.

CESAER and SEFI both have wide representational roles in the field of European Engineering Education. They have been engaged in and have supported the Bologna Process since its inception. In addition, they have been very active in organising debate and investigations into the future of European engineering education. They remain committed to playing a constructive role in the creation of the European Higher Education Area and the European Research AREA. They have produced this communication in order to present to the wider Higher Education community and to political decision-makers their views on particular issues in the debate on the Bologna Process.

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