Research and Innovation of Engineering Education in Europe the contribution of SEFI

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Abstract

The roots of engineering education lie in the workplace. It was not until the 19th century that higher engineering education moved to a more scholarly environment. True to its origins, research in the applied sciences never aimed at pure understanding alone. The goal of engineering investigations has always been to devise solutions to practice problems with a mixture of design, construction and innovation. If the establishing of a research tradition in engineering has taken quite a long time, the time needed to apply an academic mode of thinking to the approach to teaching and learning has been much longer. In fact, most of the design choices concerning the curricula in higher engineering education were made based on intuition, rather than on insight, until well over the half of the last century.

Aiming at to support the development of engineering education in Europe, in 1973 the European Society of Engineering Education was established (labelled SEFI according to the French acronym Société Européenne pour la Formation des Ingénieurs). Presently the society represents 196 institutional members. SEFI promotes cooperation between higher engineering education institutions and other scientific and international bodies on issues of research and development in Engineering Education, for instance through participating in European network projects such as the SOCRATES Thematic Network "TREE" (Teaching and Research in Engineering Education in Europe). SEFI is also engaged in policy development regarding engineering education publishing statements regarding issues like the Bologna process and the proposed European Institute of Technology. In the future SEFI aims to consolidate and strengthen its role in the European arena and to represent Europe on the Global stage.

Keywords: SEFI, Engineering Education Networks and policy, Educational research

1. Introduction

The following paper is about research and innovation of higher engineering education in Europe. Since this title harbours several potential sources of misunderstanding, the topic may need some clarification. First we should agree on a general understanding of what engineering is. Next, we must define higher engineering education and finally, we need to agree on the meaning of the concepts of research and innovation. The paper will subsequently outline a brief history of Engineering Education in Europe. Next, the role of research in educational innovation in highlighted before we get to a description of the role of the European Association of Engineering Education. To conclude we will discuss some a few topics from recent actuality.

In trying to define the position of engineering, we have to recognize the professional image of engineers as a coin with two sides. If you ask people in the street what a typical engineer will do for a living you will get answers like, they are the guys that build bridges, oilrigs, airplanes, ships and more things like that. The public sees engineers as the people that design and construct mechanical devices to make our life easier. But at the same time they think engineering is difficult (rocket science), it involves a lot of mathematics and (maybe therefore) it is mostly boring. Engineers themselves preferably underscore the creative and enterprising aspects of their jobs. Engineering graduates identify career paths as an engineering specialist and as a manager [1]. When they are hiring engineers, employers tend to look for more than just technical skills and competencies. In a paper on Engineering competencies De Graaff and Ravenstein point out that multinational technology companies, such as Shell specifically search for graduates distinguishing themselves in the area of interpersonal skills, besides of course a satisfactory level of engineering skills [2]. An engineer must be able to cooperate effectively in a multi-disciplinary team, and quite often these days also be able to operate in a multi cultural environment and most importantly to prepare for a career of life long learning.

Engineering education is the training that prepares young people for a career in engineering. One would tend to assume that higher education in engineering would simply train people for the highest level of professional qualification. In part that assumption is correct. However, it must be stipulated that most European countries recognize two ways towards a higher engineering degree: the University of Technology and the Applied

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著者の了解を得て転載しました。

Universities or Polytechnics. The Bachelor- Master structure that was agreed in the Bologna declaration provides us with a tool to describe this situation, but it does not solve the problem.

In the academic tradition every researcher is a scholar, searching to understand the world. For engineers that means no to stop at the point of a working contraption, but to go on until you understand what makes it work. Innovation and research are alternating processes, which are both needed to bring engineering to the next level. Research also is a learning experience. Students who are exposed during their formal education to research will be encouraged to develop a questioning and inquiring mind and will be less likely to accept uncritically and passively the "truth" as propounded and handed down in the lecture books and by the professional "expert" [3]. Research stands at the foundation of all teaching and learning in a university [4]. Training in engineering research is an integral part of the educational programme. Research on engineering education is needed to rise above the level of intuition and tradition in designing new engineering curricula.

2. Traditions of Engineering Education in Europe

Engineering is a practice oriented profession. For a long time the workshop was the place where new generations of engineers were trained 'on the job'. In most European countries professional organisations controlled admission to the ranks qualified engineers. The conditions as well as the developments in engineering education are different for each country. However, the establishment of the first École Polytechnique at the end of the 18th century in France, is usually identified as the start of institutionalisation of higher engineering education. This engineering school was founded as a response to the general universities, with roots back to the 13th century in Italy and France [5]. In European history, the next important phase was the German Humboldt University, built on the idea that research and teaching belong together. Research and Science were closely connected in the creation of technology and together they formed the foundation of engineering education.

In most European countries higher engineering school were established during the 19th century. For instance Delft University of Technology in the Netherlands was established on 8th January 1842 by the Dutch King Willem II. At that time however, the school was a Royal Academy, not yet a university. About twenty years later the Royal Academy was brought under a new law on secondary education. The name was changed to 'Polytechnic School' and the courses were extended to include training of architects, and engineers in the fields of civil works, shipbuilding, mechanical engineering and mining. The academic level of the School's technical education – and the right to award PhD's was acknowledged in 1905, when the school officially became an 'Institute of Technology'. Yet, to gain the name of Delft University of Technology we had to wait until 1986.

Even without full academic credentials the Polytechnic schools fulfilled an important role in society. The career of the French mathematician and engineer Henri Poincaré at the end of the 19th and the beginning of the 20th century provides a good illustration of this point [6]. Poincaré graduated in 1879 as an ordinary engineer at the École Polytechnique. At that time fierce discussions were going on relating to the balancing of theory versus applying of knowledge in practice. In 1871 France had lost a war to Germany, and the French engineers were blamed for the defeat. The age of colonial expansion was over. The European nations were competing with each other in every feasible arena: exploration, science and technology. Much later in his career, in 1903, Poincaré was to give an address at his old school: "On the part played by the Polytechnicians in the Scientific work of the 19th century". At that time he could count the blessings of the École Polytechnique. Among the alumni of the school he noted famous scientists, generals and engineering entrepreneurs. As he set out to explain this wide array of successful fields, he – as a mathematician – recognized the importance of mathematical training that had been the hallmark of the Polytechnics right from the start. But, as he pointed out it is not just about mathematics. When you have a closer look you will see that our mathematicians and our physicists are all a bit 'mechanicians'. That is what Poincaré identified as the factory brand of engineers.

3. Research and innovation of engineering education

Exploring the frontiers of human knowledge goes hand in hand with teaching and learning in the respective knowledge domains. Research, which is shifting the frontiers of science, is the best guarantee to be in touch with the state of the art, and teaching shall be done up to this top level. Therefore characteristically university staff is involved in research. Engineering education research has interdisciplinary roots and there are various research projects on different topics and using different methods. Research in engineering is usually empirical and quantitative in nature, except for design oriented research, which applies often qualitative methods [7]. Research on engineering education usually derives its methods from the social sciences

Following the increase of student numbers during the sixties of the last century, the interest in research and innovation in higher education boosted. Most Universities in the North West of Europe established research and development centres to improve teaching through educational research. In the Netherlands, the various educational centres joined forces in an informal CRWO¹ network. The network includes both general universities as well as Universities of Technology. The CRWO network continued to organize study conferences [6]. Also a

¹ Centers for Research on Higher Education (<http://www.crwo.nl/>)

section Higher Education was established as a thematic group operating within the national framework of educational researchers. The CRWO has played a mayor part in the start of educational research in the Netherlands. Until today the CRWO continues to organize annual study conferences, in recent years focusing on the role of the educational consultant rather than on research.

The Universities of Technology in the Netherlands participate in the national CRWO network. However, the development of Engineering Education takes place on the European platform. Therefore, it is not surprising that the Dutch schools have also been involved in SEFI right from the start.

4. The role of SEFI in sustaining Engineering Education in Europe

The European Society for Engineering Education was founded in 1973 in Brussels, the capital of Belgium and the sea of the European commission. The acronym derives from the name in French: Société Européenne pour la Formation des Ingénieurs. SEFI's mission is to contribute to the development and the improvement of the engineering education in Europe. It promotes information exchange about the current developments in the field, between teachers, researchers and students in the various European countries. SEFI aims to develop the cooperation between the higher engineering education institutions and promotes cooperation with industry acting as a link between its members - 196 institutional members in 38 countries - and other scientific and international bodies. SEFI works through her thematic working groups: Curriculum Development, Continuing Education and Lifelong Learning, Physics, Mathematics, Information and Communication Technologies And Women in Engineering, Ethics) and task forces which deal with topics like the Bologna Declaration and Accreditation.

SEFI plays a major role in promoting research on Engineering Education in Europe. Both at the annual conferences and at seminars and workshops participants are challenged to exchange experiences with innovative educational formats. See below for the themes of a few recent Annual conferences:

- New Engineering Competences: Changing the Paradigm! (Copenhagen, 2001)
- The Renaissance Engineer of Tomorrow – Innovation, Interdisciplinary and Flexibility in European Engineer Education (Florence, 2002)
- Global Engineer: Education and Training for Mobility (Porto, 2003)
- The XXI Century: The Golden Opportunity for Engineering Education (Valencia, 2004)
- Engineering Education at the Cross-Roads of Civilisations (Ankara, 2005)
- Engineering Education and Active Students (Uppsala, 2006)

- The 2007 Annual Conference will be organized jointly with IGIP and hosted by the University of Miskolc on 1-4 July 2007 on the theme of “Joining Forces in Engineering Education towards Excellence”.

Dissemination of new insights on Engineering Education is promoted through a bi-monthly scientific journal, the European Journal of Engineering Education, published by Taylor and Francis. Recent theme issues, with specially appointed Guest Editors, concentrated on theme s like: Assessment in Engineering Education, Sustainability, Ethics, New Competencies in Engineering, Gender studies in engineering and engineering education.

5. Key projects and networking

SEFI initiates and cooperates with other organizations in Engineering Education in Europe like CESAER², BEST³ and IGIP⁴ in international projects. In these coalitions CESAER represents the research oriented Universities of Technology, BEST is the organization of engineering students in Europe. IGIP is sister organisation with roots in the German language area and a substantial number of members in the east of Europe. Recently, the cooperation with the IGIP has been getting more intensive. The presidents of both organisations have signed a declaration in which they state their intention to look for a maximum of synergy between the two Societies and to start a process of convergence towards a common pan-European (international) Association for Engineering Education, with the main scope of promoting its quality, internationalisation and competitiveness within the many different existing education systems. It is still too early to say what this cooperation will bring us, but the potential is clear: acting together the two organisations can gain in impact in the European arena.

As early as 1995 SEFI has promoted an EEIG (European Economic Interest Group) together with CESAER and BEST applying at the EC for funding. The project was called “Increasing European Dimension of engineering education” and has established, for the first time, a wide network amongst top-schools in Engineering and Technology for investigating, discussing and suggesting major changes /improvements/good practices to all EE stakeholders [8] The networking effect was quite successful so that, once the SOCRATES

² the “Conference of European Schools for Advanced Engineering Education and Research” (www.cesaer.org)

³ the “Board of European Students of Technology” (www.best.org)

⁴ the Institute for Engineers Pedagogy (www.IGIP.com)

programme was shifted towards the “Institutional approach” (SOCRATES II), the initiative was taken by the University of Florence (a very active Institution within SEFI) to launch the E4 Thematic Network (Enhancing Engineering Education in Europe. This project has been running from 1999 until 2004 [9]. The success of E4 can easily be seen from the number of participants. More than 120 universities have joined the project, whose main results have been widely spread [10]. After the ending of E4 the EC explicitly asked the University of Florence to continue this successful project, by proposing a follow up. The theme of this new project should be focus on the synergy between Engineering Education and research. Therefore, in September 2004, the TN TREE (Teaching and Research in Engineering in Europe) has started operating again with a substantial partnership of about 115 engineering schools [11].

TREE is organised in four main streams of activities:

1. The Tuning Line: new curricula for the two-tier structure of higher education, tools for quality assessment and assurance, accreditation, extension of ECTS;
2. The Education and Research Line: status and promotion of doctoral studies, role of research activity in EE, value of research oriented project work;
3. The Attractiveness of Engineering Education Line: aiming at attracting young people, especially women, as engineering students.
4. The Sustainability Line: sustaining EE institutions by developing continuing education, and/or open and distant learning opportunities and to study ways to make valuable tools to improve EE.

The direct participation by the schools representatives increased, as it was demonstrated by the successful attendance to the first plenary meeting of TREE (more than 120 participants; Rome, February 2005).

6. Recent developments: the Bologna process EUR-ACE and the EIT

6.1. *On the road from Bologna to Bergen and beyond*

The Bologna process was initiated by politicians and signed by the ministers of European countries in June 1999. The process aims at the harmonization of the structure of university education in Europe and to facilitate mobility. Important aspects are a common structure with two levels: a Bachelor and a Masters degree and the introduction the ECTS as a uniform system to account for study load. The Bologna process brings about specific problems in the field of studies of science and engineering. SEFI and CESAER have collaborated closely on this issue, bringing out a number of joint statements. In relation to the proposed Bachelor/Master structure the two organisations agree that The 3+2 model has become a standard reference in Science and Engineering study programmes. However, 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. 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.

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. However, there appears to be a need for the identification and compliance requirements of legal and of financial procedures to make these joint degrees possible. The harmonization of the engineering curricula provides opportunities for further improvement. For instance, 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. With this in mind SEFI was one of the organisations that took the initiative to start with EUR-ACE

6.2. *EUR-ACE*

Following in the wake of the Bologna process there is obviously a growing interest in Europe for accreditation of engineering education. Accreditation has a long history in Europe, especially, in France and United Kingdom. However, the professional organisations traditionally tend to protect their own national interests. Free exchange of goods and services in the European community means the protective national barriers will have to come down. Instead this opens new windows of opportunity of accreditation and quality control at the European level. SEFI is one of the parties involved in setting up EUR-ACE, a SOCRATES project aiming to set up a European system for the accreditation of engineering education, with the FEANI in the lead⁵. Right for the start SEFI's position on European Engineering Accreditation has been aimed at strengthening the European dimension in Engineering education. SEFI defends the position that the creation of a European Accreditation Board similar to ABET is neither feasible nor desirable. A European Accreditation should respect the cultural rich diversity among European higher engineering universities, encompassing both the research oriented university curricula and the applied engineering programmes.

⁵ The European Association of Engineers; http://www.feani.org/EUR_ACE/EUR_ACE_Main_Page.htm

SEFI is of the opinion that in order to be successful, a European system for accreditation should work on the basis of cooperation and mutual recognition between existing national accreditation authorities. The Washington Accord as well as the Paris Accord could in this respect serve as possible models. The EUR-ACE project successfully ended in December 2005 and resulted in the creation of the European Network for the Accreditation of Engineering Education –“ ENAEE” –, aiming to promote the implementation of accreditation practice for engineering education systems in Europe. Guillianio Augusti, former president of SEFI and the 2004 laureate of the Leonardo da Vinci medal is one of the leaders of this process.

6.3. EIT

In 2005 the chairman of the European Commission José Barroso launched the initiative to establish a European Institute on Technology as a counterpart of the leading US top universities (MIT, Stanford, Berkeley, Carnegie-Mellon). As a reconnaissance for the feasibility of this project the EC set up a consultation round aiming to allow stakeholders to state their position towards the EIT. The following statements summarize the position SEFI defended in this consultation round. SEFI decided to support the initiative of chairman Barroso. We believe the EIT could strengthen Europe's knowledge- triangle of research, education and technology transfer". Pointing out that there are several highly reputed Engineering Education Institutes in Europe, SEFI feels the EIT in the long run could achieve outperform any traditional top university operating in one single physical location. In order to reach its ambitious goals the EIT must attract top international students and researchers: the two populations appear to reinforce each other, since top professors attract top students and the other way around. Effective organization of technology transfer, with the related question of a centralized versus a decentralized management, is a key aspect for success. Other key factors will be a very good working environment, a strong commitment of the research teams, and an enthusiastic search for continuous development. All these factors suggest that the selection for membership in the EIT network needs to be based on outstanding performance both in the field of research and in teaching. Finally, but not the least important SEFI points out that the financial resources for the EIT must not be deducted from other commitments for higher education. It should be financed with "fresh money".

7. Conclusion

SEFI operates in a culturally and politically diverse environment. Although they may be quite alike if you look upon it from the outside, the European nations each have got their own traditions and sentiments when it comes to the training of engineers. Only quite recently the politicians have started a process of turning the Economic European Union effectively into a Knowledge Society. The harmonization of the European Higher Education Area provides opportunities for different modes of collaboration. New initiatives like the EIT demand responses from professional organizations like SEFI. That means SEFI has the opportunity to gain influence in an area of decision making that did not exist as such when SEFI was founded.

In order to make the most of these changed conditions, SEFI will have to adapt. We will have to change from a non-political organization, aiming at the sharing of experiences, fully respecting the integrity of the national traditions and values, to a more professional operating platform. SEFI has to become an organization that dares to take a stand to defend a position beyond the national interests of single members.

SEFI is still a relatively young organization and we have full confidence that we will be able to make this change successfully. We can assure you that SEFI in close concert with brother and sister organizations like CESAER and IGIP will continue to promote the idea of the European dimension in higher engineering education and acts for the visibility of the vision of European Engineering Education in the world.

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Biography

Erik de Graaff is trained as psychologist and holds a Ph.D. in social sciences. In 1994 he was appointed as associate professor in the field of educational innovation at the Faculty of Technology Policy and Management of Delft University of Technology. Since 2003 Dr. de Graaff is a member of the Administrative Council of SEFI (the European Society of Engineering Education) and in September 2005 he was elected Vice president of SEFI. He is also chairman of the Curriculum Working Group (CDWG) of SEFI and he is a member of the executive committee of the International Working group Active Learning in Engineering Education (ALE).

Claudio Borri, full professor of Computational Mechanics of Structures, University of Florence (Italy), is President of SEFI (2005-07), Vice-Dean for International Relations and Vice-President of the Interuniversity Research Centre on Building & Environmental Aerodynamics; he is Author or Co-Author of approx 120 scientific publications and Editor of three books. Prof. C. Borri has been awarded in 1994 with the "M. Plank Research Award" in Structural Mechanics by the M. Plank/A. von Humboldt Found in Germany, and in 2001 with "Honorary Doctor Degree in Engineering Sciences" by the University of Architecture, Civil Engineering & Geodesy (UACEG) of Sofia, Bulgaria. Prof. Borri has been President and Legal Representative of E4 Thematic Network and is presently President and Legal Representative of TREE Thematic Network.