European Quality Level and Accreditation of Integrated Engineering Studies Programms. A major asset for employability of Engineers and Engineering Education Towards Innovation and Sustainability

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Conference Key Areas: Accreditation of engineering education, Quality assurance engineering education and Sustainability in engineering education

Keywords: quality, accreditation, innovation, employability

INTRODUCTION

1 GENERAL

The advances of Science Technology Innovation (STI), the continuous changes of the global environment, the increasing threats by various risks and the out bursting socio-economic crisis, are challenging engineering at all levels: profession, education, employment and socio-political role. Lessons learned from local, national, international projects, intrinsically linked, teach us the need to investigate, to document, to share, to compare, to evaluate engineering profiles, features and curricula in order to figure out a strategy to bridge the gap between Academia, Industry and Policy. Lessons learned from problems solving approach teach us that the emergence of opportunities requires the convergence of tools and innovations, as well as, synergies of global partnership in order to implement the goals pursued.
Today, even though, 15 years after the Bologna Process, the markets insists to prioritize the employment of engineers, Master Degree Holders (mainly arising from Integrated 4 or 5 years Study Courses), with higher salaries, as well. In the engineering field this requires the harmonizing of future priorities of the EHEA, as to “provide quality Higher Education for all, to enhance graduates’ employability and to strengthen mobility”.

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In this respect, it becomes of utmost importance, to strengthen the 5 years curricula of engineers in order to exercise the profession at the highest level of technical responsibility since we have the experience that 3+2 years is not equivalent to 5. SEFI as European Forum bridging Universities and Higher Education Institutions, provides a unique opportunity in unifying the engineering qualifications versus education programs, keeping up at the same time with the gradation of the technical responsibilities' levels, accordingly.
Hence, EQAA has to face the challenge to accreditate Engineering or other relevant integrated curricula directly at Masters Level, with no intermediary diploma as a prerequisite, inferring to a polyvalent EHEA, capable to face problems in a changing environment and at high risk conditions.
The task of attaining Sustainability of European Higher Engineering Education is critically connected with the reshaping of the Engineering Profile, the furthering of qualifications with skills as well as the enabling of Engineers to regenerate the development of local and regional economies via the employment of new tools and new technologies for the future.
Towards these dynamics innovation, sustainability and entrepreneurship have to trans-cut graduate and post graduate studies' programs and research outputs.
The case of Greek Engineering Universities and Schools, with 5 years uninterrupted Studies Programs is a pilot exemplar in this directions.
The 'global' severe economic crisis, which affected Europe even, worse, has its effect on multiple aspects of our daily lives in all the nation states of the European Union and beyond. The consequences of this crisis for European Higher Engineering Education (HEE), could damage the quality of Engineering Education if European Institutions are not ready to confront this crisis in a sustainable and effective way. In this analysis the focus is on the reshaping the Engineering Curricula keeping the quality of the Studies programs, making them efficient giving the students all the knowledge, skills and competence that the industry needs introducing new educational methods that assure the knowledge that an engineer needs along with its capability to confront changing and risk situations. In order to achieve that, this analysis will try to clarify the actual situation and at the same time feed the discussion, because with no doubt the current crisis will continue to challenge the educational establishment. In this path the accreditation as well as the assessment and evaluation of Studies Programs must take under consideration academic criteria, arising from measurable elements of the Universities performance. Such criteria could be besides the quality of the educational materials, the research achievements of the members of the community, as well as the career outcome of the students of each University.
In this, the European Commission is introducing the U-Multiranking System, in order to evaluate the Universities, considering all aspects of University activities. SEFI with the help of Universities all around Europe made a clear statement supporting this initiative, suggesting criteria and methods in order for this evaluation system to be integral and with efforts to imprint the situation, regardless economic and size criteria which are the strongest in other evaluation systems.

2. EUROPEAN QUALIFICATIONS FRAMEWORK, THE VEHICLE TO CONNECT INTEGRAL QUALITY STUDIES PROGRAMS AND THE NEEDS OF INDUSTRY

2.1 EQF, Quality Studies Programs and needs of Industry

The European Qualifications Framework (EQF) acquires the following, in my opinion suitable for the Engineering Qualifications. Regarding knowledge an Engineer should

have “highly specialized knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research critical awareness of knowledge issues in a field and at the interface between different fields”.
The skills arising from that knowledge give the Engineer specialized problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields, making him able to “manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches, take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams” [1]
Stating the above, Institutions and Industry should manage to cope for reshaping engineering studies programs contributing to the improvement and modification of the educational curricula and procedures. Moreover Universities organizational structures should reshape as well, introducing innovative aspects and components of the curricula, designing, planning and leading major initiatives and programs towards the coupling of engineering universities with the industrial and economic institutions and organizations.

2.2 The CDIO approach

There are two high-level objectives within contemporary engineering education which are in apparent conflict: educating students in an increasingly broad range of technologies, while simultaneously developing students’ personal, interpersonal, and system-building skills. To reach these objectives a Conceive-Design-Implement-Operate (CDIO) aproach is nessecary in order to create a rational, complete, universal, and generalizable set of goals for undergraduate engineering education. [2]
The Engineers graduating from Univerisities should be able to CDIO complex value-added engineering systems in a modern-based environment. The graduating engineers are expected to appreciate engineering processes, to be able to contribute to the development of engineering products, and to do so while working in engineering organizations.

In order for the Studies Programs to follow this model a very simple and clear way must be adopted. 25% of the lessons in an Engineering Program should consist of Basic Sciences lessons such as Mathematics, Physics, Chemistry etc, along with the Basic lessons of each Curiculla, i.e, basic Chemical Engineering, or Civil Engineering lessons for these two professions. Accordingly other professions of Engineering should follow the same path. The next 50% of the lessons in a Studies Programm should consist of Core lessons in each Profession. For example for a Chemical Engineer Physicochemistry, Thermodynamics, Heat and Mass Transfer Phenomena, Materials etc should be given in a way that the student understand and be able to implement the core of its profession [3]. The rest 25% of the lessons given, should be lessons that consolidate the knowledge. To assure these innovative Pedagogics in Engineering should be applyied along with instructional educational methods and processes. The implementation, already adopted in Universities in Europe will lead towards “hands-on” engineering and problem based learning performance (PBL), combining teamwork with personal responsibility and evaluation per student, through in situ, lab and PC lab work, applied projects and presentations.

2.3 The Problem Based Learning Model, to achieve CDIO

A PBL model [4] should conist of:
- Activity-based learning is a central part of the PBL learning process, requiring activities involving research, decision-making and writing. This can motivate and give the student the opportunity to acquire deeper learning.

- Inter-disciplinary learning relates to problem orientation and participant-directed processes, in that the solution of the problem can extend beyond traditional subject-related boundaries and methods. This principle is critical for organizing the teaching, so that teachers do not just consider objectives within the known subject-oriented framework, but also consider problems or real situations.

- Exemplary practice is concerned with ensuring that the benefits derived by the student are exemplary in terms of the objectives. This is a central principle, as the student must gain a deeper understanding of the selected complex problem. However, there is an inherent risk with PBL that a sufficiently broad overview of the subject area is not provided. The students must therefore acquire the ability to transfer knowledge, theory, and methods from previously learned areas to new ones.

- Group-based learning is the last principle, whereby the majority of the learning process takes place in groups or teams. Personal competencies are thereby developed, so that students learn to handle the process of group co-operation in all its stages [5]

These lessons should rely on the interdisciplinarity which is necessary for practicing an Engineering Profession, giving the students the capability to cope with others, in changing and risk environements, to give them the skills to work in a team with a clear personal contribution.

For this, the structure of the above mentioned lessons should include case studies problems where the students will work as a team, practicing in new technologies and innovative projects, practicing directly in Industries which co-operate with the Universities, making their own research efforts under the guidance from their Professors, creating perhaps innovative ideas which could be financed. [6]

In this stage the Universities structures should be prepared accordingly in order to give their students the opportunity to ”create”. The innovative entrepreneurship coming from the students acquire Univerisites prepared to finance these efforts with money coming from Industry, stake – holders, the State, Banks etc. By this the employability will be reinforced helping the overall economy towards development, in high added value areas and fields. [7], [8], [9]

In the PBL procedure mentioned above the co-operation between Universities and Industry is crucial. Profession oriented practicing periods in accordance with Studies Program, and needs of Industry should be established in an effective way which will provide the essential feedback for the changes and improvement of the program. For this, Career Office Liaison Services for student, should play the role of an active intermediate between Univerisities and Industries, informing students, providing information and opportunities, introducing the needs of Industry in Universities and vice versa.

Reshaping Engineering Curricula will allow the introduction of all the major issues pre profession in Education. For example Energy issues, Sustainable Development issues, Environmental issues, Telecommunication issues etc.

The next step towards an interdisciplinary reshaping of Engineering Education and Studies Programs is the quality assurance and accreditation issue. 15 Years after the implementation of Bologna process policies, the critique against Bologna's "success" in declining degrees, certifications and such does not especially hold water when referring to Higher European Education because so far the offering of either Master of Engineering or Master of Science choices of studies has been the most characterizing norm of engineering programs. Also the industries were not in favor of the 'bachelor as engineer' reform and continue to favor the 4 and 5 year duration studies. This justifies the needed reform of the Bologna Process, since Engineering has to face the above challenges and in order to continue to play the significant and necessary role to society, the Society alongside the End-Users (*who will put the services of Engineers to use*) as well as the Professionals, Technical Chambers and Academic Community should clearly define the Engineering qualifications; in this way, the quality of Engineering professional services will be safeguarded for the public benefit and the Universities will be able to further improve the quality of educational services offered. [10]
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3. SYNERGIES AND STRATEGY FOR QUALITY ASSURANCE AND ACCREDITATION

SEFI as a major European Engineering Institutional Organization has as members Universities from all over Europe which provide Education to Engineers. The Studies Programs in these Universities vary from 3 – 5 years. SEFI has today to strengthen the 5 years curricula of engineers in order to exercise the profession at the highest level of technical responsibility since we have the experience that 3+2 is not equivalent to 5. SEFI provides a unique opportunity in unifying the engineering qualifications versus education programs, keeping up at the same time with the classification of the technical responsibilities' levels, accordingly.

The ENAEE (European Network for Accreditation of Engineering Education) on the other hand as an organization that assures quality and provide accreditation to Program Studies, should work together with Universities and Organizations like SEFI, towards quality assurance and accreditation of Engineering Studies Programs after their reshaping, considering also the reform of Bologna process which need to be done. [11]

The needs of industry, the preferations of labor market, and the benefit of society will define the proper actions in order to bridge the gap between education and industry/society, developing quality and competence Curricula, capable and skilled Engineers assuring the flexibility which is essential today. 4 and 5 years Program Studies should be given the opportunity to be accredited as Master's level (in Engineering or Science) Studies Programs, if they meet certain specifications know and clear to everybody. On the other hand 3 years Studies Programs' graduates will also have to play a significant role in job market, and there must be a clear and stated opportunity to "jump" to the next level, by expanding the knowledge needed,

or/and having the labor experience which will allow them to cope with the next levels' technical responsibilities and required skills.
For this in every member state all over Europe, Universities along with Ministries, Technical Chambers or Associations of Engineers should come together and configure a system that clarifies the terms and the outcomes.

4. THE EXAMPLE OF THE GREEK SYSTEM FOR ENGINEERING DIPLOMAS AND PROFESSION (12)

An example towards the implementation of this strategy is the Greek System. Under the Greek laws and Constitution the accreditation of engineering diplomas has as follows:
The Greek Constitution states the Autonomy and Self Management of Public Universities. The Greek Universities are under the auspices of the Ministry of Education and by the Hellenic Quality Assurance and Accreditation Agency is accrediting Engineering Studies Programs and University Diplomas, after evaluation. The Studies for an Engineering diploma are integral and have a 5year duration with 300 credit units of the ECTS system. The student must contact, write and support a diploma thesis at the 10th semester of its studies.
The professional accreditation according to the law is provided by the Technical Chamber of Greece, which provides professional licenses. In order for a graduate to take a professional license there must be a classification at a basic discipline (there are 9 major disciplines, and over 1.200 sub categories in these disciplines with total or partial cover of professonal rights to the basic discipline). An authorised committee evaluates the graduate through exams based on the diploma thesis and known issues of his/her profession. The committee provides a professional license to exert the engineering profession at the highest level of technical responsibility.
The levels of technical responsibility are based on educational levels. The Highest Level of technical responsibility can be exercised by 4 or 5 year integral diplomas of Technical Universities and Schools and the engineer is responsible for study, supervision and integrated application works.
The 2nd (Mid-Level) of technical responsibility is exercized by 3 – 4 years educational programs focusing on technical applications (not University level), which provide partial technical responsibility for application of works and participation in study groups or supervising committes. For these graduates there are certain procedures on how they can access the next level of technical responsibility.
Finally on the 3rd and lowest level of technical resopnsibility, will be technicians at various levels. Technical responsibility for application of works under supervision.

5. CONCLUSIONS

This example, taking into account the specific needs and circumstances of each country could be a background material for consultation, in order to achieve consensus between the member states, pushing Engineering Education and Engineering Universities to a sustainable path towards development of local and regional level, as well as help the industry and the labor market have the engineers they need for the public/social benefit. A Road Map is necessary in order Universities, and European Organizations to perform the reshaping keeping the quality of studies.

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