Re-engineering Engineering Education in Europe

Abstract
According to the European Commission’s Agenda for the Modernisation of Europe's Higher Education (HE), profound reforms are needed in key areas: to increase the quantity of HE graduates at all levels; to enhance the quality and relevance of human capital development in HE; to create effective governance and funding mechanisms in support of quality, relevance and excellence; and to strengthen the Knowledge Triangle between knowledge, research and innovation. Moreover, the international mobility of students, researchers and staff, as well as the growing internationalisation of higher education, have a strong impact on the need for change and improvement each of these key areas.

Engineering schools/universities and their collaboration with industry and the engineering professions play a crucial role in achieving the targets of a smart, sustainable and inclusive growth.

The grand societal challenges faced by humanity, especially the economic crisis, environmental sustainability, climate change and demographic aging, have an enormous impact on decision-making both at policy level and on people's everyday lives. Although the transformations brought about by digitalisation and globalisation were recognised years ago, their revolutionary force was neither realised early enough nor taken seriously enough in HE. The role of universities has throughout the history been to be forerunners of change by analysing the complex trends and challenges in the development of knowledge and in society. Universities emphasize new ways of creative thinking and collaborative activity for all sectors and aspects of modern societies. Universities play a key role in mobilising local and regional actors – and a bottom-up approach is a prerequisite and warranty for the desired change.

In the light of this, the paper intends to present an analysis of the changing role of universities and report on the modernisation of university activities and higher education policies while keeping in mind the following three streams of targeted outcomes:

1) Developing structures, processes and operations in the university-society interface to better respond to the need for new answers to the grand societal challenges;
2) Developing practices to increase the societal impact of engineering schools/universities, their visibility and their attractiveness;
3) Developing new activities between engineering education and the engineering profession in order to enhance the transfer and co-creation of knowledge and the mobility of engineering students, researchers and professionals.

Keywords: Networking, Collaboration, Attractiveness of Engineering Education.

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1 Although already used in a previous publication (see reference n. 6) the present paper offers a completely new perspective and therefore justifies the use of the same title, also partly announced as one of the key topics of the conference.
1. **INTRODUCTION**

While the EU2020 Strategy [...] put knowledge at the heart of the Union’s efforts for achieving **smart, sustainable and inclusive growth**;], the European Modernisation Agenda for higher education acknowledges the importance of modernising the universities in Europe to ensure the success of the Lisbon Strategy and create an increased global and knowledge-based economy. It seems evident that a key word in order to obtain answers and suggestions to the aim of creating a society that can offer quality lifelong learning, together with growth and jobs, is exactly change through “networking”. Another key word should be “innovation” and creating original and visionary projects in the sector of engineering education would certainly be a response to the future needs.

With this in mind, one could argue that one answer to the above aims could be to create top-level groups of experienced actors in engineering education (grouped into a wide network) whose main challenge would be how to ensure that future collaboration in this sector can become self-sustainable. In this way it will continue to contribute to the promotion of a creative and competitive engineering education and the employability of future engineers with the necessary competences that can match the needs of the labour marked. As far as Europe is concerned, an example of a project that would be in the forefront as far as innovation is concerned is the FLORENS Group, originated from the LLP/ERASMUS Academic Network EUGENE (European and Global ENgineering Education) which explicitly promoted the creation of a special interest group devoted to ensure the sustainability of the networking effects of the project. The FLORENS Group was first established in Lisbon, at the occasion of the first world Engineering Education Flash week (September 2011), and work is currently in progress in order to implement further the visions of the former network. In fact, among the motivations behind the transformaton of such a group in an academic network is to create an incubator for a volountary/spontaneous, permanent and self-sustaining group and to organize top-level, highly relevant and action-oriented fora with different action-oriented discussion in line with the EU2020 Strategy and the Modernisation Agenda. The FLORENS group would certainly be on the cutting edge and an innovative project in the field of engineering education in Europe and hopefully this group will become an academic network in the future.

2. **ENGINEERING EDUCATION UNDER THREATS**

Faced with challenges such as the current economic crisis and high unemployment rates in Europe, ensuring that engineer students acquire the necessary key competences identified by the 2006 Recommendation (2006/962/EC), in order to be competitive in the labour market, is not necessarily sufficient. As argued for later in the Council conclusions of 11 May 2010 (2010/C 135/03), it is essential that individuals not only acquire a strong set of competences but that they maintain interest in the lifelong learning process and understand the importance of further developing and adapting their skills. The same conclusion also stresses that [...]there is now also a need to clarify, and to consider developing, the link between the various existing European initiatives aimed at strengthening citizen’ competences and at providing a greater focus on learning outcomes [...] and invites Member States to support the exchange of best practices. The employment of engineers is an extremely important asset to take into consideration and in light of the economic crisis that began in 2008 it is important to consider that the higher education sector has an important role in contributing through their collaboration in monitoring the effect of this crisis on the employability and try to analyse how the EU countries have responded in terms of interventions adopted in the sector of higher education in engineering.

In addition, the rapidly changing scenario in Europe, with ever larger immigration flows, in particular from the Northern Africa countries, imposes again the burning issue of the Mediterranean HE area and its integration with continental Europe: this factor gives to the
3. **INDUSTRY-UNIVERSITY COOPERATION**

As the socio-economic growth and competitiveness of the production system is definitely “technology driven”, and mainly based on innovation and entrepreneurship, education in Engineering and Technology becomes a priority for the industrial/professional corporate world and there should be a bilateral interaction and cooperation between them in order to obtain the shared aims of having graduates that fulfil the requests and have the necessary competences that matches the needs of the labour marked.

It is obvious that the technical universities are facing one of the most crucial challenges of their fairly short history: in each industrialised country they either will be able to cope with the growing demands coming from Society, or they will have to accept the existence of more and more alternative solutions for engineering training and therefore to play a less important role than in the past and that they would like to have. This awareness from the part of the educational institutions has to be shared by the governmental bodies which are responsible for the funding of the initiatives, which will be considered valid to update the system.

A key role in proposing, evaluating, and finalising these initiatives can be played by the strict collaboration of industries and universities. Such a collaboration can assume various forms. In each region or perhaps, generally speaking, in each (homogeneous enough) industrialised district, joint industry-university committees may be constituted to evaluate the existing engineering curricula and propose and/or judge about the necessary updating initiatives. It has been pointed out that even the basic methodology, which is normally offered to first and second year students, has to be updated, introducing disciplines, once considered too specialised, and now emerging as a necessary background of every engineer, such as Informatics, Operations Research, Statistics and Probability. To find time for these disciplines is not an easy matter and would require to think anew about the way other more traditional disciplines of the basic engineering training are taught.

4. **EXAMPLES OF COLLABORATION**

As already pointed out, EE in Europe is in a phase of continuous evolution under the stimuli of technological change, economic globalisation, the search for quality and relevance of higher education and for Europe’s competitiveness in the Knowledge Era, and many other factors. The
ambition of the FLORENS project would be to favour this evolution towards a better system for EE, or more exactly towards a set of improved, interrelated systems.

The motivation behind the creation of the FLORENS Academic Network Project is to generate in the future an incubator for a voluntary/spontaneous, permanent (i.e., still alive and active after expiration of the project), self-sustaining group and to organize top-level, highly relevant and action-oriented fora where: 1. the main theme of the action-oriented discussion will be the cooperation of European actors in and around engineering and technology education (EE) and 2. the challenges to be met would be how to ensure that future collaboration in this sector can enhance their contribution to the promotion of a creative and competitive European engineering education and the employability of future engineers with the necessary skill requirements that can match the needs of the labour market world-wide and address the Europe’s biggest challenges. In addition will specific attention be devoted to Engineering Education Research (EER), an essential dimension in FLORENS’ agenda for the improvement and the development of strategies for solving key issues for the future of EE as a driving force in society, e.g. the need for new competences and the ability to deal with new types of interdisciplinary and complex knowledge and to apply it to the solution of regional and global issues.

The FLORENS Project, if established, would be able to deliver a number of other tangible outcomes, in particular the realisation of a set of 5 action-oriented “fora”, i.e. university-industry workshops providing an occasion for debate and progress on core topics for EE in Europe and its role in the economy and society within the global competition. The proposed topics for the five action-oriented Fora (workshops) are the following and each of them aims at providing impetus and material able to guide and encourage the transformation process needed in EE in Europe.

1. **Integration of sustainability competencies into engineering curricula**
2. **From best practices to a roadmap for European TUs to face global challenges**
3. **Modernizing universities through virtual learning environments**
4. **Enhancing the mobility of students and graduates**
5. **Retaining and attracting students in Engineering and technology for a competitive Europe**

Another innovative example of collaboration is the newly approved TEMPUS QUEECA project which aims at setting up and implementing a system of Quality Assurance of Engineering Education in Central Asian countries (Kyrgyzstan, Kazakhstan, Uzbekistan and Tajikistan), finalized to the pre-professional accreditation of engineering programmes (i.e. accreditation of educational programmes as entry route to the eng. profession). The accredited programmes must satisfy the same pre-requisites for the award of the EUR-ACE quality label, i.e. the EUR-ACE Framework Standards (EAFS) and the European Standards and Guidelines for Quality Assurance in Higher Education. This will be achieved by the creation of a network of National QA/Accreditation Agencies (and possibly a Regional Federation) able to accredit engineering programmes and authorized by ENAEE to award the EUR-ACE quality label. The QUEECA proposal was developed taking into account the very strong support towards the "implementation of national qualifications frameworks .... compatible with the overarching Framework for Qualifications of the EHEA ... [and] with the proposal from the European Commission on a European Qualifications Framework for Lifelong Learning". QUEECA intends to contribute and support this strategy in a wide Central Asian context.

With reference to the Education and Training 2020 (ET2020) framework for European cooperation, QUEECA appears to be fully pertinent to its four strategic objectives. This is the case in particular for the priority area under Objective 4 for the development of cooperation based on “partnerships between education and training providers and business, research institutes and creative industries” which is a characteristic feature of QUEECA.
All project partners will in fact contribute to the creation of an area of cooperation in order to identify and define the national frameworks and promote a reform and modernisation of the involved partner countries' HE systems (in the field of engineering and technology education), according to the Bologna process. The partners of the project will give highest priority to international and institutional cooperation: this will allow to reach the envisaged outcomes of enhancing the quality and of bridging the partner countries with EU developments.

This project is furthermore an example of how cooperation actually has produced excellent tangible results in the past and how these are being continued in the future through new projects. This project is in fact based on the success of former project as the EUR-ACE system was devised by the EUR-ACE project (2004-2006) and started to be implemented thanks to other EC-supported programmes, i.e. EUR-ACE IMPLEMENTATION (2006-2008), PRO-EAST (2006-2007) and EUR-ACE SPREAD (2008-2010). The EUR-ACE system has also been quoted as an example of good practice of QA of higher education in a Report of the European Commission dated Sept. 2009. The EUR-ACE Framework Standards have been built in a best-case scenario (the EU) and have been successfully implemented also in non-EU Country like Russia.

Harmonisation according to EUR-ACE will constitute a very important challenge to increase employment and trans-national mobility of engineers by facilitated cross recognition of degrees in Europe and worldwide, responding to the 2006 communication by the European Parliament on “Modernisation Agenda for University”. In synthesis, the main aim of the QUEECA project is to promote the adoption of the EUR-ACE system in the partner countries, thus increasing the impact and attractiveness of Bologna principles in HEIs: the achievement of QUEECA will give a significant contribution to the implementation of the Bologna process among the involved partner countries and region. Several target groups are potentially interested by the award of EUR-ACE labels: a) employers are guaranteed of the quality of graduates from an EUR-ACE-accredited programme, without the necessity of direct knowledge of the contents and outcomes of the educational programme the graduates have followed; b) HEIs can advertise their EUR-ACE-accredited programmes stating that their learning outcomes have been recognized as satisfactory from both the academic and the professional viewpoint; c) students are guaranteed of the quality and professional relevance of their degree, if EUR-ACE-accredited; d) eng. professional organizations can be satisfied about the educational requirements of the EUR-ACE graduates who want to enter into their registers. QUEECA is therefore a great opportunity to extend the EQF and the ENAEE assessment procedure model into Central Asian countries, thus facilitating the trans-national recognition of educational and professional qualifications of eng. graduates.

5. **Enhancing Attractiveness**

“Mobility is one of the main objectives of the European Union's education and training policy, provided for in Articles 149 and 150 of the Treaty. Not only does it help to develop European citizenship and European awareness, by increasing understanding of cultural and linguistic diversity, it also supports the creation of a European area of education and training, in accordance with the strategic objective of the European Council of Lisbon of March 2000” (COM (2005) 450, 1). Under this principle the European Union has been working for more than three decades in promoting the mobility of students through various programs such as ERASMUS, grade level, and ERASMUS-MUNDUS for Postgraduate level. In fact higher Education institutions currently understand the idea of student mobility as the possibility of completing part of their studies towards a certain degree (a period of time, course or subject expressed as a number of credits) at another higher education centre in the same country or abroad. This is among the reasons why the EU institutions have adopted a number of instruments related to mobility also in the perspective of making the European Higher Education Area an attractive pole for non European students.
There is wide recognition of the importance for the competitiveness of Europe for there to be a sufficient supply of appropriately qualified scientists and engineers. There is also a recognition that across Europe the demand for studying engineering programmes at universities is unlikely to result in sufficient numbers of graduates that meet this need. Consequently an important priority which has been unanimously recognised at EU level is to increase the attractiveness and the competitiveness of Engineering studies and with this respect the authors believe that particular attention must be paid to the PhD level. The necessity of expertise within the Engineering Education (EE) community in Europe to explore the competitiveness and innovation capabilities of PhD studies in Technology in Europe is nowadays mandatory, in order to identify the barriers for third countries student entries in Europe and to overcome them. In fact, recent studies show very clearly that the balance of incoming/outgoing students to/from EU countries is evidently negative for Europe. Despite the strong qualification and well known reputation of many European schools at PhD level, some invisible barriers due to:

a) different languages & cultures (otherwise an incomparable richness of our continent);
b) access and participation conditions, which are often very cumbersome and non-transparent;
c) lack of visibility to a wide community of potential candidates from all over the world still create unavoidable problems which reduce the overall attractiveness of PhD students from third countries towards Europe.

The “Perception of European higher education in third countries – outcomes of a study by the Academic Cooperation Association” - is a vast study which clearly points out that Europe is disadvantaged with regard to US and Australia as a destination, in particular for Asian students. Furthermore, “students rank the US first for issues connected to innovation, competition and dynamism” and in most academic and labour-market related issues.

In addition to that, a thorough need analysis of PhD studies in Science and Technology in Europe (as seen from third countries and regions and carried out by international organisations like WFEO) demonstrates that non-European PhD candidates mainly look towards Europe and consider PhD courses mainly as an entry route to research and higher-level consulting and less a 3rd level of higher education. Therefore, especially in the Engineering and Technology sector, this leads to an additional problem of attractiveness, as the PhD level is often considered only a continuation of the 2 previous HE cycles, and not specifically an autonomous, independent and creative path (often in cooperation with industry) for opening new ideas, topics of research and breaking frontiers of innovation.

To overcome all above trends, the European education system must become much more known and open in wider areas and regions of the world. International networks of EE stake-holders can offer this opportunity that lead to a significant change of the situation, by drastically improving and enhancing career prospects and promoting intercultural understanding. The main issue would be to provide clear and coherent information about the quality and excellence of European Higher Education and what it actually offers to students and promote thereby the opportunities available for students. With regards to one of the barriers listed above, that the existence of different languages & cultures in Europe should hinder attractiveness seems in a certain sense to be contradictory since diversity is only a plus and an added value and gives students the opportunity to obtain additional experiences. The fact that each country is different and is identified not only by a different language but also a different culture is an incomparable richness of our continent. One could also argue that the task of assisting students in responding to the high expectations coming from a knowledge society includes to make them understand the value of not only their academic background but also the intercultural experiences matured during their study period. A experience of study abroad will in fact enhance their future career possibilities since this is highly valued by the knowledge society

Promotion of international cooperation between the European Union and third-country higher education institutions and in particular the facilitation of institution-based mobility is a win-win
situation for its potential contribution to the mutual enrichment of nations and to a better understanding of people. Institution-based mobility has the capacity not only to improve the results of education, but also to create long lasting links and generate mutual enrichment and understanding between the peoples. Among the cooperation methods available in this context, the ERASMUS MUNDUS action offers a unique occasion for the enhancement of cooperation and training opportunities and to ensure that Europe's higher education sector acquires a degree of attractiveness in the wider world equal to Europe's major cultural and scientific achievements.

6. CONCLUSION
As our society is facing many grand-challenges and threats, such as the current economic crisis, environmental sustainability, climate change and demographic ageing, these are obviously having different impacts on Higher Education. Therefore Higher Education Institutions should, or better have to contribute to identify the ways out. Universities play a key role and should be involved in providing a cutting edge and effective platform for communication and collaboration among all stakeholders in engineering education that share the same interest. Experience has proven the importance of cooperation in the European and trans-European policy context of the Lifelong Learning Programme and TEMPUS and it is precisely this activity that should be promoted in the future. The key theme is now the necessity of collaboration in engineering education in the future and more precisely, how this must contribute to creating and promoting creative and competitive education in the engineering sector and how future engineers should be assured with the necessary skill requirements and subsequently an employment. The methodology to adopt is welcoming contributions and inputs from all actors in engineering education, from students, researchers, teachers, professionals and industry, since the basis of collaboration is to include and not to exclude.
References


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