



**Innovation in research and engineering education:
key factors for global competitiveness**

*Innovación en investigación y educación en ingeniería:
factores claves para la competitividad global*

TOWARDS A EUROPEAN ENGINEERING CURRICULUM. THE TEMPUS QUEECA PROJECT

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Abstract

The growing worldwide globalization of both productions and services requires, in the sector of the engineering professions, a concomitant globalization of the engineering curricula. Nowadays engineers are increasingly engaged in international projects; they should be able to work on multinational teams all around the globe collaborating on a common project through real-time electronic communication. Successful and effective collaboration requires not only the ability of participants to communicate in a common language, but also the assurance of a common level of technical understanding. Such issues are not trivial, given the global diversity of systems for educating engineers, for different goals in skills, for quality control of their education, and for regulating their professional practice. Consequently from the engineering education perspective the accreditation and the assessment of academic programmes is critical in order to maintain the quality and the status of engineering graduates, and hence the technical workforce. In this respect the Europe-based EUR-ACE system, started in 2007 and run now by ENAEE (European Network for Accreditation of Engineering Education), represents an effective framework and accreditation system that provides a set of standards that identifies high quality engineering degree programmes in Europe and abroad. The EUR-ACE system represents a systematic and shared global model of engineering accreditation that can be used to assess global professional skills and attributes of engineering graduates. The attractiveness of the accreditation system is shown also by its spreading toward neighbouring countries of Europe. The paper, discussing the added value of the EUR-ACE accreditation system as a European best practice example, aims to present the main outcome of the Tempus project QUEECA (Quality of Engineering Education in Central Asia) launched at a kick-off meeting in Villa Vigoni (Menaggio, Italy) in November 2012, and led by the University of Florence, School of Engineering, under the leadership of Prof. Claudio Borri. The project aims at setting up and implementing a system of Quality Assurance (QA) of Engineering Education (EE) in Central Asia countries, finalized to the pre-professional accreditation of engineering programmes (i.e. accreditation of educational programmes as entry route to the engineering 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.

Keywords: accreditation of engineering education; curriculum development; diversity in engineering education; quality assurance engineering education

Resumen

La creciente globalización mundial de producciones y servicios requiere, en el sector de las profesiones de ingeniería, una globalización simultánea de los currícula de estudios en ingeniería. Hoy en día los ingenieros se dedican cada vez más a proyectos internacionales; deberían ser capaces de trabajar en equipos multinacionales de todo el mundo colaborando en un proyecto común en tiempo real a través de la comunicación electrónica. Para que la colaboración pueda ser exitosa y eficaz tiene que ser garantizada no sólo la capacidad de los participantes de comunicar en un idioma común, sino también un nivel común de comprensión técnica. Estos asuntos no son triviales, dada la diversidad global de los sistemas que constituyen la educación de ingenieros, los diferentes objetivos en habilidades, el control de calidad de su educación, y la regulación de su ejercicio profesional. Se deduce que desde la perspectiva de la enseñanza de la ingeniería, la acreditación y la evaluación de los programas académicos son fundamental para mantener la calidad y el estado de los graduados de ingeniería, así como la mano de obra técnica. En este sentido, el sistema de EUR-ACE con sede en Europa, iniciado en 2007 y dirigido actualmente por ENAEE (European Network for Accreditation of Engineering Education), representa un sistema eficaz de acreditación que proporciona un conjunto de normas que identifica los programas de grado de ingeniería de alta calidad en Europa y en el extranjero. El sistema EUR-ACE representa un modelo global sistemático y compartido de la ingeniería de acreditación que se puede utilizar para evaluar las competencias profesionales globales y las habilidades de los graduados de ingeniería. El atractivo del sistema de acreditación se muestra también por su difusión hacia los países vecinos de Europa. El documento, discutiendo el valor añadido del sistema de acreditación EUR-ACE como un ejemplo de buena práctica europea, tiene como objetivo presentar los principales resultados del proyecto QUEECA Tempus (Quality of Engineering Education in Central Asia) puso en marcha en una reunión en Villa Vigoni (Como, Italia) en noviembre de 2012, y dirigido por la Universidad de Florencia, Escuela de Ingeniería, bajo la dirección del Prof. Claudio Borri. Objetivo del proyecto es la creación e implementación de un sistema de garantía de calidad (QA) de la Enseñanza de la Ingeniería (EE) en los países de Asia Central, destinado a la acreditación pre-profesional de los programas de ingeniería (por ejemplo, la acreditación de los programas educativos como vía de entrada a la profesión de la ingeniería). Los programas acreditados deben cumplir los mismos requisitos previos para la concesión de la etiqueta de calidad EUR-ACE, es decir, el EUR-ACE Framework Standards (EAFS) y los Criterios y Directrices para la Garantía de la Calidad en la Educación Superior Europea.

Palabras Clave: *acreditación de la educación en ingeniería; desarrollo del currículum; diversidad en la enseñanza de la ingeniería; control de la calidad en la educación en ingeniería*

1. Introduction

The the EUR-ACE system, started in 2007, is a Europe-based accreditation system, run by the European Network for Accreditation of Engineering Education (ENAEE), in which a common quality label (the EUR-ACE® label) is awarded to engineering educational programmes that satisfy a common basic set of standards (the “EUR-ACE Framework Standards for the Accreditation of Engineering Programs” (ENAEE, 2008) that were elaborated in the first EUR-ACE project) and are accredited by an Agency fulfilling appropriate Quality Assurance (QA) prescriptions, in particular the European “Standards and Guidelines for

Quality Assurance in Higher Education” (ESG) adopted in 2005 within the “Bologna Process” by the Bergen Ministerial Conference (ENQA, 2010). By definition, the EUR-ACE[®] label ensures the suitability of the accredited programme as entry route to the engineering profession (“pre-professional accreditation”). Engineering programmes that have been accredited by a EUR-ACE authorised agency can be awarded the EUR-ACE[®] label (Augusti, 2011).

Unlike the old national rules that prescribed inputs in term of subject areas and teaching loads, the EUR-ACE Framework follows the trend of the most recent Standards, and define and require “learning outcomes”. This approach has several direct advantages, like: 1) it respects the many existing traditions and methods of engineering education in Europe; 2) it can accommodate developments and innovation in teaching methods and practices; 3) It encourages the sharing of good practice among the different traditions and methods; 4) it can accommodate the development of new branches of engineering (Augusti, 2010; Borri and Maffioli, 2007). EUR-ACE has been quoted as an example of good practice of QA in Higher Education in an official report by the European Commission and in an EU publication (“The EU contribution to the European Higher Education Area”) issued on the occasion of the March 2010 “Bologna Anniversary Conference” (European Commission, 2006 and 2010). The EUR-ACE system incorporates the views and perspectives of the main stakeholders (students, higher education institutions, employers, professional organisations and accreditation agencies). Among the main characteristics of the EUR-ACE[®] label one can surely recall that it encompasses all engineering disciplines and profiles, is internationally recognised and facilitates both academic and professional mobility. Moreover it gives international value and recognition to engineering qualifications, and is awarded to programmes which fulfil the programme outcome standards as specified in the EUR-ACE Framework Standards. Finally it respects the great diversity of engineering education within the European Higher Education Area and has created a quality system for accredited engineering degree programmes that share common objectives and outlooks (Borri and Tesi, 2009; Augusti and Guberti, 2011).

The EUR-ACE has already reached a total of more than 1.200 labels awarded now by 9 Agencies based in nine EHEA countries (UK, Ireland, France, Germany, Russia, Turkey, Portugal, Rumania and Italy).

2. The EUR-ACE Accreditation Model

As above mentioned, the Bologna process has resulted in the EHEA in Europe, in a common qualifications framework comprising the 1st (bachelor), 2nd (master) and 3rd (PhD) degree cycles. Components of the framework include the EQF (European Qualification Frameworks) qualifications and the ECTS credit system. European standards for internal and external quality assurance are proposed.

The EQF relies on stated learning outcomes that are rather general and applicable across all university education sectors. In order to effectively guide education design and accreditation processes for specific fields, more detailed learning outcomes need to be defined. As a result, “sectoral EQFs” emerged with the aim of developing the high-level EQF characteristics into detailed learning outcomes that should characterize specific professional degrees. In the field of engineering, the EUR-ACE framework standards (ENAE, 2008) are taking this role. They include three main parts:

- i) Programme outcomes for accreditation;
- ii) Criteria and requirements for programmes assessment and programme accreditation;
- iii) Procedure for programme assessment and programme accreditation.

3. The EUR-ACE Programme Outcomes for Accreditation

The EUR-ACE programme outcomes describe the capabilities required of graduates from 1st and 2nd cycle engineering degree programmes. They are structured in six main categories, that is Knowledge and understanding, Engineering analysis, Engineering design, Investigations, Engineering practice and Transferable skills. The 2nd cycle version both adds progression with respect to the 1st cycle outcomes, and adds some additional outcomes, for example “Work and communicate effectively in national and international contexts” (Borri, *et al.* 2012).

4. EUR-ACE Guidelines for Programme Assessment and Accreditation

The second part of the EUR-ACE framework standards includes the guidelines for programme assessment and accreditation. It is stated that a programme that seeks accreditation should have in place:

- Programme educational objectives consistent with the mission of the Higher Education Institution and the needs of all interested stakeholders (such as students, industry, engineering associations, etc.) and programme outcomes consistent with the programme educational objectives and the programme outcomes for accreditation.
- A curriculum and related processes which ensure achievement of the programme outcomes.
- Academic and support staff, structures (study halls, laboratories, and so on), facilities, financial resources etc adequate to accomplish the programme outcomes.
- Appropriate forms of assessment which attest the achievement of the programme outcomes.
- A management system able to ensure the systematic achievement of the programme outcomes and the continual improvement of the programme.

Accordingly, the guidelines for assessment and accreditation are divided into five main sections: Needs, objectives and outcomes, Educational process, Resources and partnerships, Assessment of the educational process and Management system. For each of these sections, criteria, requirements and related evidence that should be included in the accreditation documentation are identified.

5. EUR-ACE Procedure for Programme Assessment and Accreditation

The EUR-ACE accreditation process can be split in two different, but strictly correlated, phases: a self-assessment phase (Borri, *et al.* 2012) and, then, an external evaluation.

The self-assessment is implemented by a team according to the request of the accreditation model. The Team is selected inside the school and, often, is constituted by academic, technical and support staff, students. As a result of the self-assessment activity a report - denoted as self-assessment report - is written by the Team with details in accordance with the five main sections mentioned above. A particular attention is voted to the description of the skills regarding the professional figure of engineer. In this case, it is fundamental to distinguish the differences, in terms of skills, among the three different learning levels - bachelor, master and PhD.

The self-assessment report represents the starting point for the second phase of the accreditation process. On the basis of the content of such report and the performance of the learning path, an accreditation Team prepares a site visit at the University. This phase is also denoted as peer review. The site visit should include meetings with the university management, academic and support staff members, current and former students, and employers; visits to facilities (libraries, laboratories, etc.); and review of project work, final papers etc. In other words the goal of the site visit is to verify the compliance of the self-assessment activity and the contents of the report with the real situation.

For this reason it is fundamental the meetings scheduled with different stakeholders during the site visit. At the end of the site visit, feedback from the accreditation team is presented during the closing meeting. The accreditation team then writes a report, often denoted as accreditation report. The fulfilment of each individual quality requirement is assessed, using a scale with at least the following three levels: Acceptable; Acceptable with prescriptions; Unacceptable. The overall achievement of the requirements is also evaluated using a scale with at least three levels: Accredited without reservation; Accredited with prescriptions; Not accredited. The university has the opportunity to check the report for factual errors. The final accreditation decision is taken by an accreditation institution, and may be valid for up to six years with surveillance in the time. After that time, re-accreditation is required.

6. Spreading of the EUR-ACE Accreditation System

If coupled with rigorous Quality Assurance rules, as it should always be, programme accreditation assures that an educational programme is not only of acceptable academic standard, but also that it prepares graduates who are able to assume relevant roles in their professional life.

The participation of non-academic stakeholders in the process is a guarantee to this effect. An internationally recognized qualification like the EUR-ACE® label, added to the national accreditation, is facilitating job mobility as well.

Having this in mind it is fair to state that the spreading of the EUR-ACE system has received further impulse and concrete contribution from EUGENE (Borri, *et al.* 2011; Borri and Guberti, 2011), that devoted to these actions a full Activity Line led by Prof. Giuliano Augusti. Moreover, as far as present and future activities are concerned the current QUEECA TEMPUS project (see paragraph 4 below) and the perspective QUEENA (Quality of Engineering Education in Northern Africa) project (now, only a TEMPUS application under the evaluation of the European Commission) represents important steps towards as massive spreading of the EUR-ASCE system beyond the borders of the European Union.

Going back to the roots of the whole EUR-ACE adventure we must not forget that original motivation behind EUR-ACE was, and still is, to establish a pan-European accreditation system of quality engineering education that is extensively accepted by the broad engineering stakeholders community: indeed, the lack of such a system involves still great difficulties in trans-national recognition and mobility of European engineering students and graduates.

7. The Quality of Engineering Education in Central Asia: the Tempus QUEECA project

Among the efforts to spread the EUR-ACE system, one cannot forget to mention the current QUEECA TEMPUS project, which has received a grant from the European Commission for the period 2013-2015. The project, now fully operative since its Kick-Off meeting held in November 2012, aims at setting up and implementing a system of Quality Assurance of Engineering Education (EE) in Central Asia countries, 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, through the following steps:

- i) Create a National EE Society where it does not exist (in Kazakhstan, strengthen the existing KazSEE) and a CA Federation of EE Societies, partnered with SEFI and IFEEES;
- ii) Adapt the EAFS and formulate analogous CA Standards (CAEAS) in Russian and English;
- iii) Create Accreditation Centers in each CA country (with a Regional coordination); train the relevant “accreditors“;
- iv) Run a series of Trial Accreditations with intern. teams to test the draft CAEAS and the local accreditors;
- v) Taking into account the Trial Accreditations results, formulate the final version of CAEAS;
- vi) Conduct a first run of pilot accreditation of engineering programs and award the first EUR-ACE labels in CA;
- vii) Formulate a self-supporting financial plan for carrying out accredit after the project closure.

8. The QUEECA Project Rationale

In Central Asia (CA) countries, the need for international recognition of engineering degrees is becoming more and more important at several levels. Two types of accreditation of education are actually taking place for example in Kazakhstan: institutional - for an estimation of activity of the Higher Education Institutions (HEIs) and specialized - for a quality estimation of curricula. Institutional accreditation is organized by the Ministry of Education and Sciences and carried out by National Accreditation Centres.

The specialized accreditation is carried out by international accreditation agencies or accreditation organizations created by (or strongly connected with) professional associations. The CA governments are interested in creating and developing internationally recognized systems of educational and professional qualifications: in particular, the creation of accreditation organizations belonging to international networks is an urgent need. Kazakhstan and the other CA countries have declared their priority interest in the implementation of their Engineering and Technical programmes in analogy to the European Qualification Frameworks (EQF). However, international recognition of qualifications and programmes can only happen if the fulfilment of shared qualification standard is assessed through a periodic evaluation of study programmes by both internal QA and peer review processes. Following this growing interest towards the internalization of CA engineering degrees, the assessment procedure of the EUR-ACE system seems the natural answer to these emerging requirements.

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 among Engineering

and Technology higher education institutions: the achievement of objectives for 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) engineering 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 CA countries, thus facilitating the trans-national recognition of educational and professional qualifications of engineer graduates.

9. 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 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.

In this framework the QUEECA TEMPUS project appears to be an important asset for the European Accreditation System as it significantly contribute to its spreading also behind the European Union area. Moreover it appears important to mention that the adopted approach appears to be fully bottom up thus giving important prior guarantees on its possible success.

10. References

- Augusti, G. (2010), The EUR-ACE Accreditation System of Engineering Education: Origins and Current Status, European Civil Engineering Education and Training, EUCEET.
- Augusti, G. (2011), Programme accreditation and institutional review: both necessary for assuring quality of technical higher education”, lecture presented at the CLAIU-EU Conference: ”The formation of the engineer- international models”, Roma, 11/12 February 2011; www.claiu.org.
- Augusti, G., Guberti, E. (2011), EUR-ACE 14+: Empowering the European System for the Accreditation of Engineering Programmes, Proc. of the SEFI Annual conference 2011, Lisbon, PT.

- Borri, C., Maffioli, F. (Editors), (2007), Re-engineering Engineering Education in Europe, Firenze University Press, Firenze. 2007.
- Borri, C., Tesi, A. (Editors), (2009), La formazione e la professione dell'ingegnere: qualità e accreditamento nel confronto europeo, Quaderni della Conferenza dei Presidi delle Facoltà di Ingegneria, 7; CUES, Salerno.
- Borri, C., Guberti, E., Maffioli, F. (2011), Crucial milestone for EUGENE: from vision to action, Proc. of the SEFI Annual conference 2011, Lisbon, PT.
- Borri, C., Guberti E. (2011), The EU Lifelong Learning Programme (LLP) for the Competitiveness of European Engineering Education on the Global Scale, Proc. of the ICA2011, Chennai, 18-19 May 2011.
- Borri, C., Manfrida, G., Catelani, M., Guberti, E., Betti M. (2012), Focusing the Gap Between Teaching Profile and Professional Skills, Proc. of the First ENAEE Conference, Porto, 12-13 November 2012.
- European Network for the Accreditation of Engineering Education (2008). EUR-ACE Framework Standards for the Accreditation of Engineering Programmes, retrieved from www.enaee.eu.
- ENQA (2009). Standards and Guidelines for Quality Assurance in the European Higher Education Area, retrieved from www.enqa.eu.
- European Commission (2010). The EU contribution to the European Higher Education Area, Luxembourg, Publication Office of the European Union.
- European Commission Directorate-General Education and Culture (2006). Sustainability of international cooperation projects in the field of higher education and vocational training - Handbook on Sustainability, Luxembourg: Office for Official Publications of the European Communities.
- Education, Audiovisual and Culture Executive Agency – EACEA P9 Eurydice (2010), Focus on Higher Education in Europe 2010 – The impact of the Bologna Process, Luxembourg, Publication Office of the European Union.

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