EUR-ACE: the European Accreditation system of engineering education and its global context

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Abstract The EUR-ACE (*EUR*opean *AC*redited *E*ngineer) project (2004/06) formulated Framework Standards for the European Accreditation of Higher Education Programmes in Engineering. The EUR-ACE accreditation system is now being implemented. The European Network for Accreditation of Engineering Education (ENAEE) has been established to run the system and six Agencies have been accredited and have started awarding the EUR-ACE label in six countries (France, Germany, Ireland, Portugal, Russia, UK). Contacts are also in progress with accrediting Agencies outside the European Higher Education Area (EHEA).

Introduction

Accreditation of engineering educational programmes as an entry route to the engineering profession has proved to be a powerful tool to improve both academic quality and relevance for the job market [1]. Indeed, the word accreditation, used in the United States since the 1930s, did not find its way into European specialized literature and official documents until recently: however, historically Europe has been in the forefront of such efforts.

Within Continental Europe, formal accreditation (habilitation) started in France. A 1934 law established the *Commission des Titres d' Ingénieur* (CTI), in which not only academia but also employers and social stakeholders are represented on a parity basis. Only graduates from an programme with the CTI habilitation can use the title of *ingénieur diplômé*. At present, some 700 engineering programmes are accredited in French schools. In the UK a similar role has been played since the 19th century by

the Professional Institutions of the different engineering disciplines (branches). These institutions exempted the graduates of accredited higher education programmes from some professional admission requirements. As a result, in the UK accreditation is distinguished by discipline. In 1981 the Engineering Council UK (EC-UK) was established to coordinate and maintain the standards of the accreditation process. Thus, although there is neither in France nor in the UK a formal obligation to register in order to practice as a professional engineer, in both countries the established standards provide a strong incentive for the accreditation of engineering degree programmes [2]

In addition to Great Britain and France, engineering programme accreditation is an increasing practice in Europe, but, as described in several papers and reports (e.g., [3], [4]) the situation varies considerably from country to country. For example, in Germany, up to a few years ago all higher education programmes had to conform to strict (state or Federal) rules, which made accreditation superfluous. Bachelors and Masters programmes were introduced in the late 1990s and are gradually replacing the old programmes. Formal accreditation has been prescribed from the beginning for the Bachelors and Masters programmes, and was later extended to all programmes. A great number of German programmes have been already accredited, especially in engineering.

In Portugal, for example, accreditation of engineering programmes preceded the development of general quality assurance procedures. The Order of Engineers established its accreditation procedure in 1994, well before the establishment of an overall QA system of higher education. In other countries, quality assurance (QA) procedures are being introduced in the context of the so-called Bologna process, which is intended to establish the European Higher Education Area (EHEA). For example, in Italy, although sometimes using different terminology, programme accreditation procedures are being developed in parallel with the Bologna process.

It is fair to state that the quality of European engineering programmes is generally quite high within the context of a global standard, and, on the whole, is continuously improving (thanks not only to QA practices but also to the continuous contacts and exchanges of good practices between engineering faculties). Such exchanges have been facilitated for several decades by international associations such as the Société Européenne pour la Formation des Ingénieurs (SEFI). More recently, EC-supported Thematic Networks on Engineering Education have emerged either for the whole of engineering or for specific branches.

Motivation for a System of European Accreditation of Engineering Education (EE)

The variety of educational situations and of degrees awarded in Europe makes trans-national recognition of academic and professional qualifications rather difficult. The Bologna process is working towards the creation of a *transparent system* of easily readable and comparable degrees in the European Higher Education Area (EHEA), but as far as professional accreditation and recognition are concerned, no generally accepted system or agreement exists on a continental scale. However, in engineering several international agreements for mutual recognition of degrees and/or qualifications are active, for example, the Washington Accord (see Section 6 below). Notwithstanding the prestige of national systems and academic titles, this deficiency weakens the position of the European engineer in the global employment market.

The significance of this problem has been felt for quite some time. As early as 1994, the European Commission issued a communication on the possible synergies between the recognition of qualifications for academic and professional purposes [5]. In 1998-99 the Thematic Network, Higher Engineering Education for Europe (H3E) organized three European Workshops for Accreditation of Engineering Programmes that lead to the establishment in September 2000 of the European Standing Observatory for the Engineering Profession and Education (ESOEPE). It was quite natural for ESOEPE to respond to a March 2004 call for proposals by the European Commission (DG Education and Culture) stating that "the Commission supports the setting up and testing phase of transnational evaluation and accreditation" and "would welcome ... proposals from subject specific professional organisations developing European Cooperation in Accreditation in fields like medicine or engineering." (citation) The ensuing EUR-ACE (*EUR*opean *AC*redited *E*ngineer) project was launched in September 2004 and completed in March 2006.

The EUR-ACE Project and the EUR-ACE Framework Standards

A main outcome of the EUR-ACE (*EUR*opean *AC*redited *E*ngineer) project [6] was a set of standards and procedures for accrediting engineering

degree programmes. A preliminary detailed survey of the standards used by project partners revealed striking similarities behind different façades, which made the derivation of a set of shared standards comparatively easy. Unlike the old national rules that prescribed inputs in term of subject areas and teaching loads, all the current Standards, and consequently the EUR-ACE Standards, define and require *learning outcomes*, that is, what must be learned rather than how it is taught, an approach that has four direct advantages[1]:

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; and
4. it can accommodate the development of new branches of engineering.

The definitive text of the EUR-ACE Framework Standards [7] was finalized after successive versions were commented on by the project partners and other stakeholders, both academic and non-academic, and trial accreditations were run in a number of EHEA countries.

In accordance with the approach of the Bologna process, the EUR-ACE Standards distinguish between First and Second Cycle degrees, and identify 21 outputs for accredited First Cycle degrees and 23 for Second Cycle Degrees, grouped under six headings:

- Knowledge and understanding
- Engineering analysis
- Engineering design
- Investigations
- Engineering practice
- Transferable skills

1 The US Accreditation Board for Engineering and Technology (ABET) was the first agency to shift in the late ’90s from a primarily input-based to a mainly outcomes- and performance-based accreditation with their so-called Criteria 2000. The ABET philosophy is dealt with in detail in another Chapter of this book.

The EUR-ACE Standards also contain guidelines and procedures for programme assessment and programme accreditation that include the assessment, among other requirements, of the human resources and facilities available for the programme. They are consistent with the whole Bologna Process, and in particular with the Dublin Descriptors [8], the Framework for Qualifications of the European Higher Education Area (in short European Qualification Framework, EQF) [9] and the Standards and Guidelines for Quality Assurance in the European Higher Education Area (European Standards and Guidelines, ESG) [10], and also take into account the EU Directive on the Recognition of Professional Qualifications [11]. Indeed, the EUR-ACE Framework Standards address the five generic qualification dimensions of the EQF on each level by specifying and expanding them with regard to engineering.

In order to be as flexible and comprehensive as possible, and not to exclude any European-compatible accreditation system, the EUR-ACE Standards encompass all engineering disciplines and profiles, and distinguish only between First and Second Cycle Degrees (FCD, SCD). However, the Standards are also applicable to the accreditation of programmes leading directly to a degree equivalent to a Second Cycle Degree (conventionally termed Integrated Programmes), that constitute an important part of European engineering education, and not only in the oldest continental Technical Universities Schools.

In some European countries, in addition to the distinction between FC and SC degrees, engineering degrees are characterised by profiles; moreover, accreditation distinguishes between engineering branches (disciplines) in some countries, and not in others. The EUR-ACE Framework Standards can accommodate all these differences but they must be interpreted, and, if necessary, modified to reflect the specific demands of different branches, cycles and profiles. However, they leave to Higher Education Institutes (HEIs) the freedom to formulate programmes with an individual emphasis and character, including new and innovative programmes, and to prescribe conditions for entry into each programme.

A major difficulty in establishing programme outcomes, and of differentiating between cycles, is that of specifying an absolute standard. This is particularly so in engineering because the standard must apply consistently to the many different and overlapping branches, and should also be applicable to new branches that will emerge as a result of continuing scientific and technical developments.

The EUR-ACE Framework expresses the standard to be achieved by FC and SC graduates in the three direct engineering requirements (Engineering Analysis, Engineering Design and Investigations) by the phrase "consistent with their level of knowledge and understanding", and this level is described using the concept of the forefront of the particular branch of engineering. For instance, in the requirement Knowledge and Understanding the relevant phrase is for First Cycle graduates, "coherent knowledge of their branch of engineering including some at the forefront of the branch" and for Second Cycle graduates "a critical awareness of the forefront of their branch".

It would be extremely difficult, if not impossible, to obtain an agreed specification of the forefront for all engineering disciplines, and, even if is could be obtained, a fixed specification would inhibit innovation in programme design and teaching methods. Nor would it be relevant or applicable to new and emerging technologies. The identification of the forefront of the branch is the responsibility of the members of the accrediting panel who are experts in that particular branch of engineering, while the body responsible for the final accreditation verdict will review and assess the rationale for their decision.

The EUR-ACE Accreditation System and its Implementation

The EUR-ACE Framework Standards do not intend to substitute for natonal standards, but to provide a common reference framework as the basis for the award of a common European quality label (the EUR-ACE label). Consequently, the EUR-ACE accreditation system was envisaged as based on a bottom-up approach involving the active participation of national accreditation agencies and leading to a multilateral mutual recognition agreement. No supra-national Accreditation Board was proposed, that is, accreditation will remain the task of national (or regional) agencies. This decentralized approach, now being implemented, appears to be rather novel in the world-wide panorama of programme accreditation systems.

To implement the EUR-ACE system, ESOEPE has been transformed into the international not-for-profit association European Network for Accreditation of Engineering Education (ENAEE). ENAEE has registered the EUR-ACE trademark, and accredits (the term meta-accredits could be

used) national agencies to add the EUR-ACE label to their accreditation.

ENAEE determined that six Accreditation Agencies in six different countries (namely, Engineering Council-UK, Engineers Ireland; Order of Engineers, Portugal; RAEE, Russia; CTI, France; ASIIN, Germany) already fulfilled the requirements set by the Framework Standards and, in November 2006, accredited them to award the EUR-ACE label for a period of two years. Their accreditation, after a re-assessment including site visits by multi-agencies teams, was renewed for two more years starting November 2008.

The six countries of this initial core of the EUR-ACE system cover a variety of educational, political and social realities throughout Europe, such as to constitute a significant sample of the EHEA countries. Seventy-three (73) programmes obtained the EUR-ACE label in 2007, the first year of ENAEE operation, although only three agencies were ready to contribute. Between 200 and 250 labels are expected to be awarded in 2008.

Spreading the EUR-ACE Accreditation System

Although the six countries constituting the initial core of the EUR-ACE system are a significant sample of the European Higher Education Area (EHEA), their number is only about one-seventh (1/7) of the total 46 EHEA countries. Therefore, ENAEE is now committed not only to strengthen the EUR-ACE system in these six countries, but also to spread it into other EHEA countries. Several paths are being followed to accomplish this aim, as illustrated by the following examples.

1. The Turkish Association for Evaluation and Accreditation of Engineering Programs (MÜDEK), promoted by the Turkish Engineering Deans' Council, started to accredit programs in 2003 and became an independent Association in 2007. MÜDEK has applied to be EUR-ACE accredited. The evaluation of the application should be concluded by the end of 2008. It is hoped that this will be the first example of another accreditation body specialized in Engineering programmes joining the EUR-ACE system.
2. The Dutch-Flemish official Accreditation Organization NVAO (the only body legally authorized to accredit HE programmes in the Netherlands and Flanders) has also applied in order to allow Dutch and Flem-

ish engineering programmes to be awarded the EUR-ACE label. This will be the first example of a *general* QA/Accreditation Agency joining the EUR-ACE system pertaining to accreditation of engineering programmes. Comparable Romanian and Lithuanian Accreditation Agencies (ARACIS and SKVC) are also currently in the pipeline to apply for EUR-ACE accreditation.

3. Some of the six core agencies already accredit engineering programmes outside their own country; they have been authorized to award the EUR-ACE label also in such cases, and are starting to do so.
4. Individual HEIs from any EHEA country can apply, either to a specific Agency or ENAEE, to have their programmes awarded the EUR-ACE label. This may be another way to start spreading the system into some countries. However, ENAEE plans a more systematic effort, especially in a number of countries where a specific interest has been expressed, for example, in Italy and Switzerland. This might possibly include the establishment of a new Engineering Accreditation Agency.
5. In principle, the EUR-ACE label may also be awarded outside the EHEA. Indeed, signals of interest for this possibility have already been sent to the ENAEE Headquarters. Of course, Path 4 above can already be followed, and similar systematic actions in countries outside the EHEA may well be planned in the future.

The Global Context of EUR-ACE

Apart from the *European* context, EUR-ACE must confront the global scene, primarily in relation to the Washington Accord. This is an international agreement, started in 1989, among national accrediting bodies for engineering programmes. Full members of the Washington Accord are agencies operating in USA (ABET), UK, Ireland, Canada, Australia, New Zealand, South Africa, Japan, Hong Kong China, Chinese Taipei and Korea. Essentially, this agreement is among countries following a system of the Anglo-American type programmes, with a first cycle (Bachelor's) baccalaureate degree after three or four years of study and a second cycle (Master's) degree after one or two additional years.

The Washington Accord recognizes the substantial equivalency of programmes accredited by the signatory bodies and recommends that graduates of programmes accredited by any of them be recognized in the other countries. In this regard, the Washington Accord is analogous to the EUR-

ACE system. However, the EUR-ACE system mutual recognition stems from a common quality label awarded by the participating agencies on the basis of shared standards and procedures (the EUR-ACE Framework Standards) while the Washington Accord relies on comparable accreditation procedures, independently applied by the participating agencies.

In most Washington Accord countries one degree is the academic basis for entry into the engineering profession, therefore, the Accord recognizes only the bachelor's degree. However, this scheme is at present being questioned and there are pressures for the Washington Accord to move toward a two-tier system analogous to the Bologna/EUR-ACE scheme. Indeed, the Engineering Council UK and Engineers Ireland (that are among the original signatories of the Washington Accord and also participate in the EUR-ACE systems) have accredited Master's degrees for a number of years. Beginning in 2009/2010, ABET will also allow accreditation of engineering programmes provided by a higher education institutions (HEI) at two levels (Bachelor's and Master's).

The Washington Accord prescribes at least four years of study for an engineering Bachelor's degree. In parallel, standards have been developed for three and two-year programmes, leading respectively to engineering technology degrees and engineering technicians qualifications that are recognised in the so called Sydney and Dublin Accords. The rigid and formal connection of outcomes with years of study and semantic definitions of technical professions in this three-accord (Washington - Sydney - Dublin) system, causes difficulties in the mutual professional recognition for programmes defined within the Bologna two-cycle[2] scheme, as well as for the academic recognition of such programmes for graduates applying for admission to graduate studies.

Indeed, such problems should not exist in an outcomes approach. The assessment of certified learning outcomes and gained competences should be independent from the ways of their achievement and the time it took. In this regard, the EUR-ACE Standards, consistent with the Bologna Process and the EQF, provide a more flexible connection between outcomes and duration of study that do the Washington - Sydney – Dublin accords.

A comparison between the EUR-ACE and the Washington Accord requirements will be a crucial element in making the EUR-ACE label fully

[2] The third cycle (doctoral studies) has been recently introduced in the Bologna process but is not yet considered in any accreditation scheme.

recognized globally, if for no other reason than that two members of the EUR-ACE core are also signatories of the Washington Accord. A comparative study is being promoted by ENAEE, and contacts have also been established with the International Engineering Alliance (IEA) that embraces the three Accords, in order to accomplish this aim.

Conclusions

If coupled with rigorous quality assurance (QA) rules, as it should always be, programme accreditation assures that an educational programme is not only of high academic standard, but also that it prepares graduates who are able to assume relevant roles in the job market. The participation of non-academic stakeholders in the process of setting standards and subsequent quality assurance is a guarantee to this effect. An internationally recognized qualification like the EUR-ACE label, added to such an accreditation, will facilitate job mobility as well.

Engineering has always been in the forefront of discipline-specific accreditation, for example in France and the Anglo-Saxon countries, which has in many cases preceded the advancement of general QA procedures. Indeed, the engineering approach can be (and in some cases is) used as a model for other professional disciplines.

Discipline-specific accreditation is usually conferred on individual educational programmes rather than departments or HEIs. However, this does not exclude and, on the contrary, is facilitated by an overall system of QA that authorizes only quality HEIs to deliver academic degrees.

When compared with the Washington-Sydney-Dublin Accord system it is fair to state that the EUR-ACE system is at the same time simpler and more flexible. This is the case since it does not create a rigid barrier between engineers and technologists, which is against the spirit of the Bologna Process, and in many languages even not understandable, but allows national differences and appropriate distinction between the cycles. Benchmarking the two systems will indeed be a major challenge for EUR-ACE. At the same time such an effort will be a test of the consistency and actual applicability of Dublin Descriptors [8], EQF [9] and EU Directive on professional qualifications [11].

But, apart from technical and operational difficulties inherent in creating a European scheme like the envisaged EUR-ACE system, a major difficulty lays certainly in the great differences between educational practices, legal provisions and professional organizations across the different European countries. These are, however, the typical difficulties encountered in building a unified, but not homogenized, Europe. The fact, that common Standards could be written and can be now implemented from Portugal to Russia, in continental and Anglo-Saxon countries, is a matter of great pride for us, the initiators of EUR-ACE.

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