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Accreditation of Engineering Programmes as a tool to assure Academic Quality and relevance for the job market

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Giuliano Augusti, Ian Freeston, Guenter Heitmann, René-Paul Martin

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Giuliano Augusti[1], Ian Freeston[2], Guenter Heitmann[3], René-Paul Martin[4]

Abstract

Accreditation of engineering educational programmes as entry route to the engineering profession has been proved to be a powerful tool to improve at the same time academic quality and relevance for the job market.

Within Continental Europe, accreditation of engineering studies started formally in France, with a 1934 law establishing the Commission des Titres d' Ingénieur (CTI), but already in the 19th Century the Engineers' Institutions played a similar role in Great Britain. The present status of QA and accreditation of engineering education (EE) in these two countries is discussed in Part 2 of this paper.

In the present widespread trend for internationalization of QA and accreditation, a number of international agreements on the recognition of engineering programmes are active throughout the world, but a generally accepted pan-European system does not yet exist.

Part 1 of this paper describes the EUR-ACE system that is being set up to cover this lack. In the EUR-ACE system all engineering study programmes – irrespective of their type or profile - will be judged, on the basis of the EUR-ACE Framework Standards, whether they provide graduates with the academic qualifications necessary to enter the engineering profession at either the First Cycle (Bachelor) or the Second Cycle (Master) level. National Agencies will accredit the educational programmes, and – if they conform their procedures to the EUR-ACE Framework Standards and respect other relevant documents like the ENQA Standards & Guidelines – will be authorized to add the (copyrighted) EUR-ACE label, thus giving a European dimension to the national accreditation.

This system is at present being implemented by a "core" of six Agencies, respectively in the UK, France, Germany, Portugal, Ireland and Russia; it is expected that new Agencies and countries will soon join the system.

Generalities and background.

Accreditation of engineering educational programmes as entry route to the engineering profession has proved to be a powerful tool to improve both academic quality and relevance for the job market.

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, but then has rapidly become a catch word. The engineering community, on the whole, favours "programme accreditation" rather than the "Institutional accreditation" preferred in some Academic circles; indeed, this approach underlines that "accreditation" cannot be a process closed within academic circles, but need the participation of other stakeholders. In this context, "Quality Assurance" is not a synonym, but rather a pre-requisite, of "accreditation".

Notwithstanding this shared viewpoint, great differences in accreditation practices persist within European engineering: the present situation has been described in several papers and reports (e.g. Augusti 2005, Augusti 2006). Formal accreditation procedures are in place in an increasing number, but not yet in all European countries: however, quoting European Commission documents, 'most evaluation and accreditation is carried out on a national or regional basis' although 'it is expected that these local exercises will become more comparable and more European through the use of "an agreed set of standards, procedures and guidelines" and the involvement of foreign experts. In a limited number of cases there is scope for transnational evaluation and accreditation.

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[1] Università di Roma La Sapienza ; President of ENAEE and coordinator, EUR-ACE IMPLEMENTATION project.

[2] Emeritus Professor; Higher Education Adviser, Engineering Council UK; member, EUR-ACE Label Committee, ENAEE.

[3] TUBerlin; member of the International Advisory Board, EUR-ACE IMPLEMENTATION project.

[4] Commission des Titres d' Ingénieur, Paris; member, EUR-ACE Label Committee, ENAEE.

For instance in highly internationalised fields of study like business and engineering or in cases where universities or sponsors (public or private) seek to obtain a label for reasons of branding or consumer protection. ...' (EC, DG EaC, 2004).

A proposal for an European accreditation system of engineering education and its motivations are expounded in Part 1 of the present paper, while the examples of France and UK are described in Part 2 to illustrate the very different accreditation systems that need be accommodated in a European Framework.

PART 1

Accreditation and QA of Engineering Education in Europe: motivations for a pan-European system

At present, accreditation of engineering programmes is widespread throughout the world, but historically Europe has been in the forefront.

Within Continental Europe, formal accreditation started in France: a law dating back to 1934 established the Commission des Titres d' Ingénieur (CTI), in which not only academia but also employers and social stakeholders are represented on an equal basis. Only graduates from an accredited programme can use the title of "ingénieur diplômé", which makes accreditation ("habilitation") practically compulsory. The "habilitation" lasts a maximum of six years; at present, about 700 engineering programmes are accredited in the French Schools. Each year, CTI awards about 100 "habilitations" in France, and about 20 in other countries.

In the UK a similar role has been played since the 19^{th} Century by the Professional Institutions of the different engineering disciplines (branches): hence, accreditation was (and is) distinguished by discipline. Each Institution has been endowed with a Royal Charter, and in 1981 the overarching Engineering Council UK (ECUK) was established, also by a Royal Charter, to advance the education and training of engineers for the public benefit, and to establish and maintain the standards of the accreditation process.

More details on engineering accreditation and QA in France and UK are in Part 2 of the present paper: it will be seen that, although neither in France nor in Great Britain there is a formal obligation to be part of some register in order to practice the engineering profession, in both countries there is some "regulation" that makes "accreditation" of engineering programmes (in the above defined sense) de-facto practically compulsory.

The situation in other countries is different, in some very much so.

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. The new programmes leading to the "Bachelor" and "Master" degrees, introduced in the 1990s, are gradually replacing the old programmes: for them formal accreditation has been prescribed, and a great number of programmes has been already accredited, especially in the field of engineering.

In other countries, where QA assurance procedures are being introduced in the context of the Bologna process, procedures for programme accreditation are being developed in parallel, sometimes using different terminology: this is for example the case in Italy.

Another country in which accreditation of engineering programmes has preceded general Quality Assurance procedures is Portugal, the object of a recent survey by an ENQA panel (ENQA, 2006): the "Order of Engineers" established its accreditation procedure in 1994, well before the establishment of an overall QA system of Higher Education.

It is however fair to state that the quality of European engineering programmes is in general quite high on a global standard, and on the whole continuously improving thanks not only to the QA practices in force or being introduced, but also to the frequent contacts and exchanges between Engineering Faculties, facilitated since several decades by permanent International Associations such as SEFI (Société Européenne pour la Formation des Ingénieurs) and CESAER (Conference of European Schools for Advanced Engineering Education and Research), and lately by EC-supported Thematic Networks (Higher Engineering Education for Europe H3E; 1997-99; Enhancing European Engineering Education E4; 2000-04; Teaching and Research in Engineering in Europe TREE; 2004-2008). Nevertheless, the variety of educational situations and of degrees awarded 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", but as far as "accreditation" and recognition with professional implications, no shared project or system exists on the continental scale.

At the same time, several international agreements are active in the engineering field (the Washington Accord, the Engineering Mobility Forum, etc.) These are spontaneous "bottom-up" agreements for mutual recognition of degrees and/or qualifications; some such agreements exist sporadically also in Europe, and some (e.g. the Washington Accord) involve European countries.

Thus, notwithstanding the prestige of national systems and academic titles, in a global job market the lack of an accreditation system recognized on the continental scale puts the European engineer in a objectively weak position.

The relevance of this problem has been felt for quite some time. Already in 1994, the European Commission set up a Task Force tasked with investigating possible synergies between recognition of qualifications for academic and professional purposes and issued a Commission Recommendation based on the report of this Task Force (EC, 1994). More recently, after three "European Workshops for Accreditation of Engineering Programmes" (EWAEPs) promoted by Working Group 2 of the European Thematic Network H3E with the participation of Higher Education Institutions (HEIs) and professional bodies active in Accreditation and Quality Assurance, a few academic and professional organizations set up in September 2000 the "European Standing Observatory for the Engineering Profession and Education" (ESOEPE).

The stage was thus set for taking up the suggestion from the European Commission (DG Education and Culture) that in March 2004 issued a "Call for Proposals for Europe-wide Participation Projects contributing to the Realisation of the European Higher Education Area (Bologna Process)", in which it was stated that "the Commission supports the setting up and testing phase of transnational evaluation and accreditation... The Commission would welcome ... proposals from subject specific professional organisations developing European Cooperation in Accreditation in fields like medicine or engineering." It was thus quite natural to answer with a project proposal, namely the EUR-ACE (EURopean ACredited Engineer) project, that was submitted in April, approved in August, started in September 2004, and completed by 31 March 2006. Much of the content of this paper derives from the results of the EUR-ACE project and its developments (Augusti, 2007).

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

The EUR-ACE project started its work by comparing existing Standards for accreditation of engineering programmes, in which striking similarities were revealed behind different façades: the recent Standards are all outcome-based (i.e. the learning outcomes to be reached are stated, but it is not indicated how they should be achieved) and all lists of the areas of programme outcomes are very similar to the final EUR-ACE list:

- Knowledge and Understanding;
- Engineering Analysis;
- Engineering Design;
- Investigations;
- Engineering Practice;
- Transferable Skills.

It was thus possible to elaborate common "EUR-ACE Framework Standards", intended for use throughout Europe (and possibly beyond), in successive versions that were discussed also with non-academic stakeholders, and tested: the final version can now be found at www,enaee.eu.

The EUR-ACE Framework Standards describe the outcomes of First and Second Cycle programmes judged to provide the education necessary for the engineering profession, and are framed to encompass all engineering disciplines and profiles. In the six listed areas, all together 21 generic learning outcomes for the First Degree and 23 for the Second Degree level have been determined.

The use of educational outcomes, as opposed to the educational process, is important for three reasons.

(a) It ensures that the many different traditions and methods of EE in European countries can continue.

(b) The accreditation process will enable the spread of good practice in these existing diverse traditions and methods.

(c) The Framework will be able to accommodate innovations in methods of teaching and learning, and also the development of new branches of engineering.

Note that, in addition to the distinction between FC and SC degrees, in a few European countries engineering programmes are also differentiated according to “profiles”, in some countries the accreditation distinguishes between engineering branches (disciplines), and in some others there is no differentiation at all in the accreditation.

In order to be as flexible and comprehensive as possible, and not to exclude any “compatible” accreditation system, the EUR-ACE Framework Standards do not distinguish between different profiles, but only between First and Second Cycle Degrees, However, “the Standards [are] applicable also to the accreditation of programmes leading directly to a degree equivalent to a Second Cycle Degree (conventionally termed ‘Integrated Programmes’)”. Indeed, “integrated programmes” are an important part of European EE: not only in the “old” Continental Schools, but also in U.K., Ireland and other countries.

Since the EUR-ACE Framework Standards will apply equally to all different types or profiles of engineering study programme, they must be interpreted (and if necessary completed) to reflect the specific demands of different branches, cycles and profiles, while HEIs retain 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.

The EUR-ACE Standards are intended to be consistent with wider European development, and in particular with the ‘Dublin Descriptors’ that were incorporated in the ‘Framework for Qualifications of the European Higher Education Area’ agreed by the Ministerial Conference at Bergen in 2005 (EQF, 2005). Consequently, it is also expected that accredited programmes will fulfil the quality assurance criteria set out in the ENQA document ‘Standards and Guidelines for Quality Assurance in the European Higher Education Area’ (ESG).

The EQF did not exist when the EUR-ACE project was started in 2004, but, since it was based on the previously elaborated Dublin Descriptors and active members of the EUR-ACE project were involved in Bologna Seminar discussions in 2004 (Edinburgh) and 2005 (Copenhagen) it was possible to refer to the EQF when finalising the EUR-ACE Standards. Indeed, the EUR-ACE Framework Standards address the 5 generic qualification dimensions of the Framework on each level by specifying and expanding them with regard to demands of the engineering profession.

The provisions for accreditation at the “First Cycle” (FC) and “Second Cycle” (SC) level, consistent with the “Bologna process” approach, are a fundamental characteristic of the EUR-ACE Framework Standards. While other international and national (especially non-European) Standards specify only one set of outcomes to be met, for each outcome the EUR-ACE Standards differentiate between the requirements for FC and SC graduates, as defined in the EQF in accord with the Dublin Descriptors. For example, the requirements for “Knowledge and Understanding” are first defined in general terms:

“The underpinning knowledge and understanding of science, mathematics and engineering fundamentals are essential to satisfying the other programme outcomes. Graduates should demonstrate their knowledge and understanding of their engineering specialisation, and also of the wider context of engineering."

and it is then specified that:

"First Cycle graduates should have:

- knowledge and understanding of the scientific and mathematical principles underlying their branch of engineering;
- a systematic understanding of the key aspects and concepts of their branch of engineering;
- coherent knowledge of their branch of engineering including some at the forefront of the branch;
- awareness of the wider multidisciplinary context of engineering.

Second Cycle graduates should have:

- an in-depth knowledge and understanding of the principles of their branch of engineering;
- a critical awareness of the forefront of their branch."

A major difficulty in establishing programme outcomes and 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 be applicable to new branches that will emerge because of continuing scientific and technical developments. In the EUR-ACE Framework the standard is described in the three direct engineering requirements 'Engineering Analysis', 'Engineering Design', and 'Investigations' by using the phrase

'consistent with their level of knowledge and understanding'

to express the standard to be achieved by graduates.

The level of knowledge and understanding is described using the idea of the forefront of the particular branch of engineering. In the requirement Knowledge and Understanding the relevant phrase for First Cycle graduates is

'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'.

These phrases invite the questions what is the forefront, and who is to determine it. It would be extremely difficult to obtain an agreed specification of the forefront for all engineering disciplines, and, even if they could be obtained, a fixed specification would inhibit innovation in programme design and teaching methods. Nor would they be relevant or applicable to new and emerging technologies. The decision on the forefront of the branch is taken by the members of the accrediting panel who are experts in that branch of engineering. The reasons for their decision will be reviewed and assessed by the committees responsible for the final accreditation decision.

The EUR-ACE Framework Standards include also "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) and finally a "Template for Publication of Accredited Programmes".

The "EUR-ACE Framework Standards" do not intend to substitute national standards, but to provide a common reference framework as the basis for the award of a common European quality label (the EUR-ACE label) which will add a European dimension to existing (and future) national accreditation procedures, as explained in the following Sections.

The proposed EUR-ACE accreditation system and ENAEE

Perhaps the most significant and novel contribution of the EUR-ACE proposals is the operational system, essential for the correct application of the Framework Standards; its basic concept was described as follows in a working document of the EUR-ACE project:

"EUR-ACE advocates a bottom-up approach which involves the active participation of present and future national accreditation agencies and which should embrace a multilateral mutual recognition agreement based on agreed Standards and procedures. No supra-national Accreditation Board should be formed: accreditation should always be awarded by a national (or regional) agency which may already be in existence or may be created in the future."

In other words, by a multi-lateral bottom-up agreement a common European label (EUR-ACE) will be added to the accreditation certificates of the National (or Regional) Agencies, either existing or to be created: this "decentralized" approach appears to be a novel approach in the world-wide panorama of systems for accreditation of engineering programmes, such that the rich experiences accumulated in decades by national bodies like the French "Commission des Titres d' Ingénieur" and the British Engineering Institutions will not be lost, but on the contrary exploited to create a consistent accreditation system of EE at the continental scale.

To coordinate and supervise the EUR-ACE system, ESOEPE decided to transform itself into the "European Network for Accreditation of Engineering Education" (ENAEE), formally founded as an international not-for-profit association in February 2006 by 14 associations concerned with EE throughout Europe (two more organizations have joined ENAEE later).

The EUR-ACE labels have been copyrighted; they will distinguish between EUR-ACE BACHELOR and EUR-ACE MASTER, respectively when the programme is accredited as FC or SC degree. Note the wording: "European Accredited Engineering Bachelor/Master"; indeed, in some countries/States to become an "engineer" it is not sufficient to be an "engineering graduate" but some training and/or professional examination is necessary: this aspect is not covered by EUR-ACE which addresses only academic formation.

Implementation of EUR-ACE.

The purpose of accreditation is to evaluate EE programmes against standards agreed and accepted by the academic community and possibly other stakeholders. Normally such accreditation is based on assessing the individual programmes, but in the EUR-ACE system a central body (ENAEE) will accredit established National agencies that already accredit (and will continue to accredit) engineering programmes (the term "*meta-accreditation*" can be used with reference to this approach) and authorize them to add the common European EUR-ACE Quality Label to their accreditation.

Each Agency participating in the system will need to explain how its procedures ensure that all three types of evidence necessary for programme accreditation are acquired and evaluated, namely: (i) the content of the programme; (ii) the standard of the programme and the attainment of the graduates; (iii) the teaching and learning environment. The first two of these are directly related to output standards, and are judged by experts. The third is not directly an output standard, but it is important to assess if the organisation and facilities of the programme, including the resources of personnel and equipment, are such that the output standards can be realistically attained by the students.

The ENAEE has established the EUR-ACE Label Committee to develop and implement procedures for meta-accrediting agencies and follow the "labelling" process, and has ascertained that six Accreditation Agencies in six different countries (namely, Engineering Council-UK (ECUK); EngineersIreland; Order of Engineers (OE), Portugal; RAEE, Russia; CTI, France; ASIIN, Germany) fulfil already the set requirements. Consequently, the six Agencies have been authorized to award the EUR-ACE label for a period of two years, after which they will be assessed again. These six countries, covering a variety of educational, political and social realities throughout Europe, will constitute the initial "core" of the EUR-ACE system: it is expected that a number of EUR-ACE labels will be granted already within the current year 2007.

In the meantime, the bases are being established for appropriate procedures able to enlarge the EUR-ACE system beyond the initial core. Three possible alternatives are at present envisaged:

1. Include other Agencies in the system, as soon as they demonstrate compatibility with the Framework Standards and associated requirements: this may soon be the case of a couple of

organizations that are already members of ENAEE.

2. In countries without any accreditation system, create a new Engineering Accreditation Agency. In the meantime, programmes may be accredited by an Agency already active in the system.

3. In countries with established “general” accreditation agencies, the Agency could require the fulfilment of specific Standards (in our case, the EUR-ACE Framework Standards) for their accreditation when this implies (or is a requirement for) professional recognition. In this case, they could be authorized to add the EUR-ACE label. Agreements in this direction are already being elaborated: they may require some modification of the described meta-accreditation system.

The global context of EUR-ACE. Outcome- vs. Input-based accreditation

The EUR-ACE system aims to take into account existing national accreditation schemes but also relevant European and global reference frameworks and regulations.

On the European scale this applies in particular to the “Framework for Qualifications in the European Higher Education Area” (EQF, 2005) and the “ENQA Standards & Guidelines” (ESG), quoted in a previous Section. Apart from this “European” context, EUR-ACE project was (and now ENAEE is) challenged to deal on a global scale with existing accreditation standards and procedures in engineering in order to facilitate the international professional recognition for EUR-ACE Bachelors and EUR-ACE Masters. It was felt absolutely necessary for the EUR-ACE label to be comparable and competing with accreditation procedures and labels in other parts of the world. This concerns mainly the standards and regulations of the US Accreditation Board for Engineering and Technology (ABET) and currently the newly defined standards of the so called Washington Accord.

In the USA accreditation as an approach for quality assurance in higher education has a long standing tradition and is at first instance an accreditation of Institutions. In addition, and in particular for professionally oriented qualifications, programme accreditation is well established. At present, ABET is a federation of 28 professional and technical societies representing all branches of engineering. Since 1934 it is carrying out programme accreditation in EE and since some time also in “engineering technology” and computer science education. ABET is recognized by the American Council for Higher Education Accreditation (CHEA) and by the US Department of Education as the only one specialized agency operating in the field of EE. The stated aims of programme accreditation are quality assurance as well as quality improvement, mainly with regard to professional requirements. This is related to the fact that in most US States to become a state licensed professional engineer applicants must have graduated from an ABET-accredited (or “substantially equivalent”) programme. Differently from EUR-ACE, accreditation by ABET is focused only on the first degree, which usually is a Bachelor degree, apart from a few cases of integrated programmes where the Master is the first degree. Current debates on the need for a dual level accreditation have not yet lead to a change in the accreditation patterns; only the American Society of Civil Engineers (ASCE) calls for an accredited degree at the Master level as necessary entry requirement to the profession and to licensing in the near future.

In the late 90’s, ABET was the first agency to shift from a primarily input-based to a mainly outcomes- and performance-based accreditation. After a test phase, the so-called Criteria 2000 are now compulsory for all programme accreditations in engineering: ABET has defined 9 criteria to which programmes have to refer. Criterion 3 is related to programme outcomes and requires 11 different learning outcomes necessary for engineering in general; they may be enhanced by additional branch-specific outcomes which respective programmes have to address. Programme providers are free to specify the programme aims according to the mission of their higher education institution and to choose different teaching/learning approaches, but need to prove by an appropriate outcome assessment that the required outcomes have been achieved at the end of the programme.

This new approach of the ABET rules has replaced a very detailed and standardized list of required in-puts, thereby supporting check-list based and inflexible “bean-counting” auditing procedures. New and promising programmes and teaching/learning arrangements had big problems to get accredited. This has now changed. First empirical investigations have shown that the outcome-based accreditation procedures indeed provide space for diversity and promote change and quality improvement. That's why from the very beginning the EUR-ACE project based its standards on outcomes

The Washington Accord, originally signed in 1989, is an international agreement among bodies responsible for accrediting engineering degree programmes, mostly in countries with a higher education system of the Anglo-American type, usually with a first cycle (Bachelor) degree after four years of study and a second cycle (Master) degree after one or two additional years. The 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 by the other bodies as having met the academic requirements for entry to the practice of engineering. Like in the USA, accreditation in most signatory countries focuses mainly on the first degree as the regular entry into the engineering profession. Full members of the Washington Accord are ABET and the agencies from UK, Ireland, Canada, Australia, New Zealand, South-Africa, Japan and Korea. Since recently Germany and Russia are provisional members, but face big problems to achieve full membership: in fact, these two countries applicants used to follow a traditional continental European EE structure (an integrated programme towards a single level degree) and have only recently changed to the Bologna dual level structure.

The Washington Accord may be compared to the EUR-ACE system, that has based its mutual recognition decisions and the right of its members to award the EUR-ACE label on common standards and procedures. However, the Washington Accord until recently relied mainly on comparable accreditation procedures, independently applied by their professionally oriented accreditation bodies; only since 2005 a list of outcome standards has been elaborated and discussed by the Washington Accord members, combined with an in-put parameter of four years of study for an engineering degree. In parallel, standards referring to the same outcome criteria have been developed for 3 years programmes, leading to an "engineering technology" degree recognised in the frame of the so called Sidney Accord, and for 2 years programmes of "engineering technicians" dealt with in the Dublin Accord.

The rigid and formal connection of outcomes with years of study and semantic definitions of technical professions in this three-accord (W-S-D) system, causes difficulties in the mutual professional recognition for programmes defined in accord to the Bologna two-cycle system, especially with regard of the "engineering" qualification of 3-years programmes, even if the outcomes required are comparable and equivalent. This problem arose already for academic recognition for 3 years Bologna type programmes when graduates of these programmes applied for admission to graduate studies in countries with a four year undergraduate education, e.g. the USA. In principle this problem should not exist if a clear outcomes approach is implemented and the achieved outcomes are equivalent. The Bologna Process and the EQF provide a more flexible connection to the duration of study and tend to follow the European approach to separate the achievement of certified learning outcomes and gained competences from the ways of their achievement and the time it took.

For the time being it must be considered that in practice the academic and professional recognition and credential policy in Europe and globally is still very much driven by comparisons of input parameters. It seems to be more accountable as long as it is not clear whether comparable learning outcomes are not only stated but really achieved. To promote mutual trust and facilitate international recognition – at least in certain professional areas – it is necessary to implement valid and reliable outcome assessment procedures, not only comparable outcome standards. The appeal of the EUR-ACE label is the outcome-based dual level accreditation in accord with the Bologna Process and various European QA approaches. It would however fail, if the EUR-ACE Bachelor would not be globally recognized as fully qualified engineering graduate prepared to enter the profession or to continue studies in engineering on the graduate level. Besides its expansion towards more European countries this problem may be the biggest challenge for ENAEE and EUR-ACE as a European discipline-specific quality label and quality assurance approach.

Overall Discussion.

If coupled with rigorous QA rules, as it should always be, programme accreditation assures that the educational programme is not only of high academic standard, but is also relevant for the proper role in the job market: the participation of no-academic stakeholders in the process is a guarantee to this effect. An international recognized qualification like EUR-ACE, added to such an accreditation, facilitates job mobility.

Engineering has always been in the forefront of discipline-specific accreditation, that in many (if not in most) cases has preceded general QA procedures, not only in France and the Anglo-Saxon countries, but also in the quoted example of Portugal. Indeed, the "engineering" model can be (and in some cases is) used as a pilot for other professional disciplines.

Discipline-specific accreditation is usually referred to individual educational programmes rather than Departments or HEIs, but of course does not exclude an overall system of QA of the whole educational system, authorizing only "quality" HEIs to deliver academic degrees.

If confronted with the other existing "global" engineering accreditation system (the W-S-D system of three "accords" described in the previous Section) it is fair to state that the EUR-ACE system is at the same time simpler and more flexible: it does not create a rigid barrier between "engineers" and "technologist" (against the spirit of the Bologna Process, and in many languages even not understandable) but allows national differences and appropriate distinction between the "cycles".

Indeed, it can be expected that the relation with the Washington Accord will be a crucial point for the implementation and the running of the EUR-ACE system, if anything because two members of the EUR-ACE "core" are also signatories of the Washington Accord. It is therefore of interest to quote from a very recent paper: "Accreditation for engineering education among the Washington Accord signatories has been focused on the Bachelor's degree level, because the Bachelor's degree level is seen as the first entry level to professional practice of engineering. However, accreditation at the Master's degree level has emerged out of different reasons among the signatories, namely Engineers Ireland and JABEE [Japan Accreditation Board of Engineering Education]. ASIIN, a provisional signatory of the Washington Accord, has also launched accreditation for the Master's degree level. IEET [Institute of Engineering Education Taiwan] will launch accreditation for the Master's degree program beginning in 2007."(Liu et al., 2007). A recommendation for accreditation at both the Bachelor and Master level has been made also by the US National Academy of Engineering: it appears that the Washington Accord might soon move towards a two-tier system very similar to EUR-ACE.

This will be another challenge for EUR-ACE, that at the same time will be a test of the applicability of the EQF, the Dublin Descriptors, and the EU Directive on the recognition of professional qualifications (EU, 2005).

But, apart from technical and operative difficulties, in creating a European system like the envisaged EUR-ACE system, a major difficulty lays certainly in the great differences between educational practices, legal provisions and professional organizations between 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 tentatively implemented from Portugal to Russia, in continental and Anglo-Saxon countries, is a matter of great pride for us, the initiators of EUR-ACE.

PART 2

a) Quality Assurance in France, and relations between academic studies and professional practices

Introduction

CTI – full ENQA and ECA member since 2005, founding member of ESOEPE and ENAEE, partners of both EUR-ACE projects - has the official mission to evaluate and accredit the engineering programmes in France since 1934. This provides to an Institution (Schools of Engineering), the right to award the Title of “ingénieur diplômé” in an engineering specialty programme. Consequently, this accreditation gives automatically the academic Master grade to the graduates (not the reverse). Both grade and diploma have a legal value (academic and professional). It is based on an academic and professional quality assurance process.

Main goals are: to support institutions in the implementation of effective internal quality assurance, to foster competence based EE, to offer its competence and experience to evaluate foreign universities who wish to increase their international visibility, in particular through mutual recognition accords. CTI considers this is better achieved within an integrated 5 years programme (300 ECTS).

The objective

The objective is to educate and train students to become an “ingénieur”, scientifically, technically and professionally adapted to the European and international economic global context, and in the rise context of an worldwide higher education area in engineering. Global excellence in engineering is the key objective.

The profession of an “ingénieur diplômé” (integrated master degree) consists basically in efficiently identifying and solving problems, often of a complex nature which are linked within a competitive organization, to design, realization and implementation of products, systems or services, and eventually linked to financing, marketing and sales. In this respect, the ingénieur must master both knowledge and skills of a technical, economic, human and social nature. These are based on a solid scientific culture.

The “ingénieur diplômé” activity is notably practiced in industry, building and civil engineering, agriculture and services. This activity mobilizes staff, technical and financial means, and often in an international environment. It receives economic and social approval, and takes into account the concern of man, life and the protection of the environment, and more generally, the collective welfare.

The “ingénieurs” (graduates) are ready to fulfil the requirements to apply and to be successful in the following functions on the labour market: R&D, Engineering, Studies and Technical Consulting, Project or Programme Management, Production, Exploitation, Maintenance, Testing, Quality and Safety, Information Systems, Customer Relations, Human Resources, General Management, Education and Research.

References and Orientations, Criteria

The principles and criteria for the evaluation of those HEI's providing EE are developed in public documents. The key CTI criteria comprise: selection of students, wide and strong base in science and technology, awareness with research, strong links with industry, international awareness

CTI Standards have been lined up with the EUR-ACE Programme outcomes for the Second Cycle (Master) level, in which the bachelor outcomes are included. This is verified across the scientific and technical, economic and industrial, personal and cultural dimensions.

In our opinion, differences between agencies QA practices are not so far in the writen programme outcomes themselves, but rather in how to evaluate them:

- The choice of indicators, their required level of excellence and proofs of evidence.
- Their direct or indirect measurements and proofs.

CTI experience is that its evaluations through the academic programmes outcomes verifications are essential but not sufficient from the professional point of view. To verify the capacity to adapt quickly to the labour situations and to facilitate an industrial career, additional means, to a strong scientific education, such as in situ industrial and international learnings, and economic, human sciences learnings with additional indicators (outputs) are used by the panel of evaluators. They may be interpreted by the role of the joint academic-professional efforts to educate and train the students in a balanced manner with measurable results. The academic and professional qualifications are jointly evaluated by an appropriately composed panel, not successively.

The discussion in this Section will be limited to four key criteria. Indicators are obtained from the output information given on the ingénieurs diplômés situation after graduation, as required by CTI. These criteria stress also the differences observed between countries.

Strong base in science and technology

A broad and deep scientific knowledge is proposed to the students: maths, computer science, physics, chemistry ... This provides a base for the understanding and learning of a large variety of complex technologies or specialties. It is also useful for adaptation to further learning. Qualified academic, education facilities, are carefully checked. The students are interviewed on the quality improvement of the education: programme content adapted to the objective and delivery.

Academic education contents are intense and respect the balance: basic sciences 35%, technology and specialty 35%, human sciences, quality, safety and economy, foreign languages 30%. Graduates are successful in further scientific studies and in complex technology and specialty programmes.

Research orientation.

The evaluation panel checks the involvement of the School in research, and R&D, activities. Professors have recognized research activities. Scientists take part in the education by delivering lectures in front of the students and education design. Students must have discovery of research experience in labs and understand the scientific activities and their contribution to innovation.

This may be evaluated by the programme outcomes and marks obtained in a wide range and deep understanding of disciplines and techniques. Outputs are also indirectly measured by the capacity of graduates to get further scientific degrees (14%of graduates) or a PhD (7% in average with up to 20% in chemistry and chemical engineering and much more in biotechnology). 40% of PhD in science and technology are ingénieurs diplômés (graduates). An average of 30% of ingénieurs diplômés are active in research or design activities and more on their entry on the labour market.

Strong links with the companies

Industry representatives on the CTI board of directors give advices at the study programme committee, juries, and on the award of research contracts. Students are exposed to industry problems solving and by “in situ” experiences as part of the education – in particular internships or apprenticeships. Programme contents in human sciences, economy, safety and environmental sciences are important to face and solve complex situations.

The rate and the quality of employment of engineering graduates in France is high: 40 % have a job before they leave the School, 92% have a permanent position less than 6 months after they are graduated. The exerted jobs correspond well to their education and their discipline. The “in situ” training is appropriate: 35% of the graduates (ingénieur diplômé) and 40% of the apprentices find their first job in their internship company.

It is demonstrated that the span of competences and skills expected from the programme outcomes, competences and skills, are duly verified by the variety of the ingénieurs diplômés (in average) activities on the labour market: Production and associated activities: 23% - Research, development, design, technical studies, consulting: 30% - Information systems: 18% - Sales and marketing: 10%- Administration, finance, human resources: 4% - General management : 8% - Education: 2%- Others: 5%. R&D, engineering studies and Information Systems represent 48% for the average population and 55% for the young graduates.

International awareness

It is a constant recommendation by the CTI to the schools and the students to develop their international awareness. It is a part of the learning outcomes to practice two foreign languages (a minimum level is compulsory to get the degree), english traning is compulsory as the working language in industry, and have gain experience abroad during their education. 70% of the graduates have spent at least three months in an other country (university or company) - ECTS. 15% get a double degree in another country.

In 2006, 36% of the ingénieurs diplômés are in charge of international activities and 15% of them find their first job in a foreign country, mainly where they spent their industrial period of study (internship). International jobs are highly appreciated by the graduates: 80% consider it is very useful for their career development. 45% of the ingénieurs (graduates) employed out of France are in 4 countries: Switzerland, Germany, UK, USA. This demonstrates that they are adapted and adaptable to the global context of the profession.

External observations concerning the satisfaction of the EUR-ACE requirements.

External observers said that: “The accreditation procedure is in accord with the EUR-ACE standard and procedures. The academic outcomes are implicit in CTI standards (they are explicit since 2006). Learning outcomes are defined as competences and skills which are central in the discussion between stakeholders and students and professors. Employers and students are satisfied by the programme. The observer can assume that the programme outcomes would certainly have been satisfied the outcomes defined in the EUR-ACE Standards. The engineering degree programme would satisfy the EUR-ACE requirements.”

Strengths and weaknesses, opportunities and threats.

Among the strengths, it is demonstrated that the model is well accepted by the HEI themselves, the students and employers are satisfied and procedures exist to react for correction. A large majority considers that their internal and external evaluations are very useful for their continuous improvement. Students and employers are systematically interviewed during the visits and express their satisfaction or dissatisfaction. There is however a clear evidence that evaluation cannot be limited to the programmes, other criteria such as institution strategic and management autonomy, management leadership, legal existence, access to sufficient financial resources are also necessary.

Final considerations

All accredited HEIs fill a form presenting the professional certifications of their "ingénieurs diplômés", in line with the text of the References and Orientations of CTI (CTI, 2005). This form is registered in the Professional Certification National Register ("RNCP"), which stands for the National Quality Framework.

However, CTI considers that the learning outcomes approach is to be encouraged (CTI, 2006) in the Institutions and verified in the evaluation process. However, their measurement is sometimes difficult, particularly for those expected from the employers. Any progress in that direction is welcomed.

CTI is deeply involved in the accreditation approaches in Engineering outside France. The EUR-ACE system and the ECA – TEAM programme should bring closer the two systems. They have in common the mutual recognition of accreditation decisions, a priority for the CTI. The two approaches have positive aspects: EUR-ACE has succeeded in elaborating a set of minimum standards in Engineering. ECA has taken a step by step comparison approach which satisfies the European standards and guidelines and the national legal value of diplomas. Both have the advantage to organize accreditation visits in other countries. France versus UK (EUR-ACE), France versus Switzerland, Germany, Netherlands, Flandre, Spain (ECA – TEAM). Such experiences gained by CTI, will help to build trust among agencies, adopt each other decisions in the future, save rising expenses and time, and make progresses towards better academic and professional recognition and mobility.

b) Accreditation of Engineering Education in the United Kingdom: UK-SPEC

In the UK, the Engineering Council (EC^{UK}) has the overall responsibility for establishing and maintaining the standards both of the accreditation of engineering degree programmes, and of the registration of qualified professional engineers. The standards for registration are framed in terms of competences published in UK Standards for Professional Engineering Competence (UK-SPEC) (ECUK, 2005), and the normal route to achieving these competences is to obtain an accredited engineering degree, followed in employment by a period of initial professional development, and then by a demonstration of professional responsibility. The typical time after graduation to achieve the competences required for registration is three or four years.

The standards for the accredited engineering degree programmes are also published in UK-SPEC (ECUK, 2004), and build on previous regulations stressing the importance of outcomes, an approach which lends itself to recognising both the diversity of higher education and the innovation of technical content in engineering programmes. The EC^{UK} does itself not conduct accreditations, but licences the discipline-specific professional engineering institutions (PEIs), such as the Institution of Civil Engineers, Institution of Mechanical Engineers, Institution of Engineering and Technology, etc, to carry out the accreditation to the standards specified in UK-SPEC. This delegation of accreditation has two advantages. Firstly, the professional engineering institutions are long established learned societies, and have large memberships of registered professional engineers, both academic and non-academic, with the expertise necessary to evaluate a wide range of programmes. Secondly, it separates the responsibility for framing the standards from that of implementing them. For degree programmes that encompass more than one traditional engineering discipline, joint panels from the relevant PEIs are organised.

Learning Outcomes

The requirements in UK-SPEC for the accreditation of engineering degree programmes are expressed as learning outcomes that apply to all engineering disciplines. They and are interpreted by each of the licenced professional institutions to reflect their particular discipline. The UK-SPEC output standards are of two types: *general learning outcomes*, which apply to all types of programmes, and *specific learning outcomes*, which are more discipline oriented. The broad areas of the output standards are:

General Learning Outcomes

- Knowledge and Understanding
- Intellectual Abilities
- Practical skills
- General transferable skills

Specific Learning Outcomes

- Underpinning science and mathematics
- Engineering Analysis
- Design
- Economic, social and environmental context
- Engineering practice

The two sets of learning outcomes are usually inter-related within a degree programme, with the general learning outcomes being embodied to a certain extent within the more discipline-oriented, specific learning outcomes.

Accreditation Visits

The accreditation process is initiated by the university department submitting to a relevant PEI documentation that explains how the degree programmes meet the learning outcomes of UK-SPEC. The documentation will include information on the details of teaching and learning, assessment strategies, the human and material resources available, quality assurance arrangements, the selection of students for the programme, and how the extremes of cohort entry standard will be supported. The PEI appoints an accreditation panel to investigate the claims made in the documentation, and to make arrangements for a visit to the university department. The panel will include academic and industrial members trained in the principles of accreditation and conversant with the requirements for accreditation.

The visits take place over two to three days and the panel meet staff and students, visit library, laboratory and studio resources, and, very importantly, scrutinise student output (i.e. examination papers, project reports, etc) to ascertain if the required learning outcomes are met. Essentially the panel is seeking evidence to confirm the claim that the content and standard of the programmes meet the specified learning outcomes, and that the resources are adequate to enable the students to achieve these outcomes.

Each PEI has a relevant committee or board which will decide, on the basis of the report from the accreditation panel, whether or not to accredit programmes. Programmes can be accredited for up to five years, although sometimes PEIs accredit programmes for shorter periods, if some aspects of the programmes are judged to require development or enhancement. Shorter periods of accreditation are also used for new programmes, the output of which may need to be monitored. All accredited programmes are listed on the EC^{UK} website
www.engc.org.uk/registration/acad/search.aspx

Quality Assurance

Engineering accreditation in the UK is complemented by the rôle of the Qualifications Assurance Agency (QAA), which is responsible for ensuring the quality of the education provided across all programmes in UK universities. The QAA conducts audits to evaluate the arrangements in universities to ensure that the teaching and learning environment is of the appropriate standard, and is properly resourced, supported and monitored. This means that accrediting panels evaluating an engineering programme can rely on the integrity of the assessment of the institutional processes, and can therefore concentrate directly on how these processes are practiced in the programmes under consideration. The QAA also publishes for each subject a Benchmark Statement which describes the 'nature and characteristics of programmes in a specific subject'. The QAA and EC^{UK} have agreed that the learning outcomes for accredited programmes published in UK-SPEC will serve as the QAA Benchmark for engineering.

Registration

In the UK an accredited engineering degree does not enable a graduate to register immediately as a professional engineer. Such a degree programme provides the exemplifying levels of understanding, knowledge and skills to support the development of the professional competences that are required in order to register with the EC^{UK} as a professional engineer. The accredited qualifications providing the underpinning knowledge and understanding are:

Chartered Engineer

- A BEng (Hons) degree and an appropriate Masters degree or appropriate further learning to Masters level, or;
- An integrated MEng degree.

Incorporated Engineer:

- A Bachelors degree in Engineering or Technology, or;
- A Higher National Certificate or Diploma or a Foundation Degree, and appropriate further learning to Bachelors level.

Subsequent to graduation, potential professional engineers learn to apply their knowledge and understanding, to develop further practical skills, and to use engineering judgement. This phase of professional development and growing responsibility lasts typically for three or four years. An applicant for registration then submits to a relevant PEI an application, which includes information about their education, professional development and responsibility. The PEI appoints trained assessors to review the application and interview the applicant. If the outcome is successful, the candidate's name is added to the EC^{UK} register of professional engineers.

Although in the UK there is no formal obligation to register in order to practice the engineering profession, the regulations for registration emphasise the importance of the accreditation of engineering degree programmes.

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