Qualification Frameworks and Field-Specific Approaches to Quality Assurance: Initiatives in Engineering and Technical Education

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ABSTRACT

"General" and "field-specific" Quality Assurance procedures, although sharing many "technical" instruments (self evaluation reports, peer reviews, benchmarks vs. reference points, etc.), have different directions. The motivations behind "field-specific" initiatives are critically presented in this paper. They are strictly correlated with Qualification Frameworks that, while preserving the autonomy of higher education institutions in defining their teaching offers, define common and transparent employability objectives for the benefit of students, graduates and all other stakeholders. However, "while learning outcomes have been generically defined for the degree structure", it is now necessary "to further develop descriptors for subject specific knowledge, skills and competences. ... leaving still plenty of freedom for programme diversity." (Bologna Process, 2009a). Qualification Frameworks and field-specific Quality Assurance lead naturally to "pre-professional accreditation" that can be given an international value by "European Quality Labels".

Keywords: *Accreditation Standards, Engineering Education, Field-Specific Approaches, Learning Outcomes, Qualification Frameworks, Quality Assurance, Technical Education*

INTRODUCTION

On 11-12th of March 2010 the Ministers responsible for higher education (HE) of the 47 countries signatory of the "Bologna Process" agreements met in Budapest and Vienna to formally launch the European Higher Education Area (EHEA).This date can be seen as the first milestone of the first decade, of a deep reform of the European systems of higher education, that aims at fostering mobility and cooperation within Europe and creating more transparent and attractive conditions for third countries to cooperate with European Universities, without intending to establish any "uniformity" of the varied picture of European HE.

The reform of the structure is there. The reform of the substance, that of developing readable curricula in a lifelong learning context and

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of developing methods that make use of modern tools and meet the expectations and motivations of young people, is about to start. To a large extent it can be said that the main goal of this second decade of the Bologna reform is about bringing "Bologna" into practice.

It should be understood that promoting mobility and co-operation, the essential objectives presiding to the construction of the EHEA, requires TRUST and that for such trust to grow it is necessary to build transparent and readable academic curricula and professional qualifications. This is achieved through transparent Qualifications Frameworks (QF) and Quality Assurance procedures (QA), recognised and accepted by all partners and stakeholders.

This paper is about two such requirements, qualifications frameworks and quality assurance guidelines and methods, issues that are intrinsically connected between themselves and to the core building block concept of Learning Outcomes (LO).

Indeed, Qualifications Frameworks based on Learning Outcomes represent a cornerstone of the reforms proposed within the Bologna Process - they play a major role in basically all main structural areas of the reform: (i) in developing degree systems and study programmes at higher education institutions; (ii) in the recognition of qualifications, by all stakeholders; and (iii) as a pre-requirement, in the implementation of quality assurance (QA) systems.

Concerning the last of the structural areas mentioned, QA systems should include clear and measurable objectives and standards: therefore, there cannot be any quality assurance without a qualifications framework. The understanding by all stakeholders of academic degrees and related specific knowledge, competences and skills of their graduates is essential for both internal and external evaluation and for recognition. This means, and the paper deals with issues in developing and implementing field-specific strategies and methodologies for QA that must be supported by related sectoral descriptors of qualifications.

What is "Accreditation"?

A very recent well-researched Ph.D. Thesis (Patil, 2010) states:

"The literature search shows that accreditation is an increasingly commonly accepted mechanism of quality assurance in higher and engineering education".

In this context the word "accreditation" is definitely related to a field-specific approach in Quality Assurance of higher education, in which the aims and contents of the educational programmes are specified, as opposed to a "general" QA approach in which essentially the quality of the teaching/learning process is assessed. Before going further, the meaning of the word "accreditation" must be accurately qualified.

As defined in the EUR-ACE Framework Standards (ENAEE, 2008a) and in their "Commentary" (ENAEE, 2008b):

"Accreditation of an engineering educational programme is the primary result of a process used to ensure the suitability of that programme as the entry route to the engineering profession."

This definition has accepted in this paper. It was written for engineering, but it may apply to different professions (the word "engineering" could be replaced by the corresponding one for another profession). It combines assurance of "academic quality" with professional relevance. Therefore, it can neither be simply qualified as "academic accreditation", nor, on the other hand, as "professional accreditation", because "academic education" may be not sufficient to be accredited for a profession: e.g., in several countries to be qualified as "engineer" a graduate of an accredited programme must fulfil further (more or less formalized) "professional training" requirements, fixed by professional, not academic, organizations. Hence, in order to avoid confusions, "accreditation", defined in this way, can be referred to as "pre-professional accreditation".[1]

GENERAL VS. FIELD-SPECIFIC QUALITY ASSURANCE

Procedures for QA are increasingly accepted, if not required, in education systems throughout the World. This is all the more true for higher education. In Europe, the reference QA document is the "European Standards and Guidelines for Quality Assurance in Higher Education" [ESG] (ENQA, 2005). This document was officially adopted by the 2005 Conference of European Higher Education Ministers, held in Bergen in the context of the Bologna Process. The ESG fix common European standards for internal and external quality assurance and for external quality assurance agencies, leaving to each provider of higher education (in the following, indicated as a "Higher Education Institution" or HEI) "the primary responsibility for the quality of their provision and its assurance". The ESG require that each HEI develops and publishes "explicit intended learning outcomes" of each provided programme, and pays "careful attention to curriculum and programme design and content". Also, "student assessment procedures are expected to be designed to measure the achievement of the intended learning outcomes and other programme objectives...".

It is relevant to note that the development of Qualifications Frameworks based on the Learning Outcomes concept is gaining growing importance: it was not even mentioned in the Bologna Declaration (1999) and in the Prague Ministers' Communiqué (2001), but figures prominently in every recent document of the Bologna Process. As e.g. the London Communiqué (Bologna Process, 2007) asks for "efforts ...on removing barriers to access and progression between cycles and on proper implementation of the [European Credit Transfer and Accumulation System] ECTS, based on learning outcomes and student workload" and further states that QFs "should also help HEIs to develop modules and study programs based on learning outcomes and credits and improve the recognition of qualifications..."

The ESG approved in Bergen refer to the "Qualification Frameworks for the European Higher Education Area" developed within the Bologna Process on the basis of the so-called "Dublin Descriptors", equally approved in the Bergen conference (Bologna Process, 2005). These are meta Qualifications Frameworks that identify levels of qualifications, employing general learning outcomes descriptors. Consistently with this approach, the ESG do not specify nor refer or quote specific subject areas.

Thus, although the ESG and in general QA practices have done and are doing a great deal to improve the European HE systems (and the same is true on the global scale) the risk is unavoidable that these, that can be defined as "general" QA procedures, lead to paying more attention to the "educational process" than to the "content" and "job relevance" of the education.

This is where the relevance of specific learning outcomes (LO) defined for more or less broad subject areas, became recognized as essential tools in the global QA processes.

"Field-specific" approaches to QA are in rapid development, an observation that is supported by documents, facts and events that took and are taking place:

i) In "Bologna beyond 2010", the background paper for the 2009 Ministerial Conference (Bologna Process, 2009a), it has mentioned that:

"...the relationship between qualifications frameworks and quality assurance is crucial. Work needs to be continued over the next few years, at national and institutional as well as at European and regional level, to improve the links and interaction between the work done on qualifications frameworks and on quality assurance, involving a broad range of relevant stakeholders... While learning outcomes have been generically defined for the degree structure [through] the 'Dublin descriptors', the key point is to further develop descriptors for subject specific knowledge, skills and competences. Since the start of the Bologna Process, higher education institutions and their academics have taken up the challenge to develop international descriptors and reference points for

a growing number of subject areas. Initiatives in this direction ... are welcomed and need further encouragement; ... [it is true that] the establishment of too detailed subject specific descriptors could hinder the development of interdisciplinarity... however, shared subject descriptors are only to be seen as indicative for a kind of core curriculum, leaving still plenty of freedom for programme diversity. Common reference points could also be developed for an entire sector, which might lead to the definition of sectoral descriptors and the establishment of sectoral qualifications frameworks".

ii) A field-specific definition of the Learning Outcomes (LO) is supported by the final Communiqué of the latest Bologna Process Ministers' Conference (Bologna Process, 2009b), where it reads: "We reassert the importance of the teaching mission of higher education institutions and the necessity for ongoing curricular reform geared toward the development of learning outcomes... Academics, in close cooperation with student and employer representatives, will continue to develop learning outcomes and international reference points for a growing number of subject areas...";
iii) The theme has been the object of a recent Conference organized by ASIIN[1] and jointly hosted by a number of subject-specific networks[2] (Wasser, 2009).
iv) The series of "TecnoTN Fora", organized by the "Archipelago of Thematic Networks in the fields of Sciences and Technology" (TechnoTN, 2009), stands as an example of positive collaborations and exchanges of experience within and between subject-specific Networks and Associations.

In the initiatives quoted above, the essential tools are specific learning outcomes (LO) defined for more or less broad subject areas. Thus, a *de-facto* European Network of Disciplinary Accreditation Organizations is growing, formed by an encompassing alliance of stakeholders, and is developing both several European Competence Profiles at disciplinary level and pan-European sets of Learning Outcomes as entry route to several specific professions (engineering, chemistry, informatics, geology, etc). These sets of LOs are developed having a number of characteristics and objectives in mind. They intend to:

- Be widely applicable and inclusive, enabling eligibility of a wide range of possible approaches to higher education;
- Handle the diversity of content of degree programmes;
- Be relevant for academic study programmes leading to a First or to a Second Cycle Degree;
- Define qualification as entry routes to the profession;
- Facilitate in particular accreditation of trans-national joint- and double-degree programmes.

Hence these LOs, applied in combination with the ESG, should lead to "pre-professional accreditation", as defined in Section 1, and Mutual Recognition Agreements for academic and/or professional purposes.

Considerations of this type have lead to the "Joint Statement" signed by the European Network for Accreditation of Engineering Education (ENAEE), the European Chemistry Thematic Network Association (ECTNA), the European Informatics Project (EURO-INF) and the World Federation of Medical Education (WFME), and presented to the London Conference of the EHEA Ministers (2007) to underline the validity of field-specific quality assurance procedures (ENAEE et al., 2007).

Field-specific and "general" quality assurance approaches share most of their QA "technical" instruments and procedures: self evaluation reports, peer reviews, benchmarks vs. reference points, etc. The choice should never be "either - or", but of how to best combine the two approaches in order to limit the burden placed on the organisation and its members and optimize the results. Being both approaches relevant, it is however clear that field-specific QA approaches accentuate the

need for aligning the goals of educational programmes with the expectations of the relevant stakeholders, in order to be comparable and ensure their relevance for the labour market, and underline that higher education institutions, while in principle autonomous, are nevertheless accountable to their constituents, which includes an obligation to demonstrate the relevance of their output. Thus, field-specific QA systems give credibility and concreteness to the whole "Bologna"/EHEA system. For the countries of the European Union, this link to the relevant social and economical issue of employability is further stressed and strengthened by the "The Directive for Recognition of Professional Qualifications" approved by the European Council and the Parliament in September 2005 (European Union, 2005).

In line with these developments, the European Commission is supporting since 2006 the establishment of "European quality labels" in selected subject areas: two very recent EC documents quote the "quality labels" in Engineering ("EUR-ACE") and in Chemistry ("Eurobachelor" and "Euromaster") as examples of good practices of QA in HE (European Commission, 2009, 2010).

The development of sectoral frameworks and subject specific LO still has a long way to go. It should be recognised that existing frameworks and related descriptors still suffer from a number of shortcomings, as tools for fostering academic and professional mobility and mutual acceptance of accreditation decisions, viz.:

- The formulation of LO are prone to internal and external political power games and the attempt to situate one's own education or educational system as favourably as possible in the national context or international realm;
- Thus far, there is no system in place to measure learning outcomes reliably across national boundaries: while in the field of secondary education there are instruments like the PISA study, no such methods are in place in the field of HE. Indeed, the very ambitious AHELO (Assessment of Higher Education Learning Outcomes) initiative launched on the global scale by the OECD Directorate for Education is *de facto* still in the planning stage because of financial difficulties, after a preliminary report was published in May 2009 (Tuning Association, 2009; Wagenaar, 2010);
- In spite of all the rhetoric on LOs, most Mutual Recognition Agreements rely on input criteria and/or on procedural similarities;
- The engagement of employers has not reached a satisfactory level.

Some initiatives can be formulated in order to overcome these shortcomings (Wasser, 2009):

- Learning Outcomes/Competence Profiles could be developed internationally (on the continental or global scale) and brought to each others' attention, in order to learn from best practice while respecting cultural diversity;
- Development of international/joint degree programmes;
- Development of joint accreditation procedures for trans-national joint degree programs;
- Development of measurable cross-national outcomes - institutionalization of international peer groups which visit institutions and programs in several countries at the same time to cross-examine the output of study programs;
- Intensification of stakeholder involvement and cooperation between the different quality assurance/accreditation structures and between HEIs and QA-Agencies: involvement of the Business Community is a crucial asset for this aim.

QUALIFICATION FRAMEWORKS AND QUALITY ASSURANCE

A Qualifications Framework (QF) expresses the expected learning outcomes for a given qualification, that is what a learner is expected

to know, understand and be able to do after successful completion of a process of learning.

In view of the arguments of the preceding section, it should be clear that QF unfold and are developed at three main levels of descriptors, related to and characterized by different levels of detail, (i) meta frameworks; (ii) sectoral frameworks; and (iii) branch level descriptors. This can be further explained as below.

Meta Qualifications Frameworks and Related High Level Descriptors

These include high level descriptors of competences, of a general nature, describing global qualifications associated to degrees. They are generally developed at institutional level of governments and stakeholders and to a large extent represent the basis for the 'legal crust'. They may differ in background and objectives, and as such different frameworks may arise, employing different sets of descriptors, or grouping such descriptors in different clusters.

At European level, two main frameworks are currently in place:

(i) The Qualifications Framework for the construction of the European Higher Education Area [QF-EHEA] (Bologna Process, 2005) approved by all the 46 countries that were part of the Bologna Process at the time (47 today, since the "Bologna Anniversary Conference" held in Budapest and Vienna in March 2010);

The QF-EHEA focus on the post-secondary education system and adopts the well known "Dublin Descriptors" that identify four cycles of higher education (three main cycles plus short cycles within or linked to First Cycles). Table 1 identifies the five building blocks that form the structure of the Dublin Descriptors. Table 2 presents the relations between the levels of qualifications adopted in the different frameworks and in the Directive for recognition of professional qualifications (a document to be discussed below).

(ii) The European Qualifications Framework for Lifelong Learning [EQF-LLL] (European Union, 2008a), a Recommendation of the European Parliament and of the Council, approved on April 23, 2008, with effect on the EU countries.

The EQF-LLL aims at describing the entire education system, recommending eight levels of qualification, each identified by descriptors grouped in the three main clusters of outcomes presented in Table 1.

The objectives of the EQF-LLL are thus different, wider in scope, from the QF-EHEA. Yet, it caused some reaction of the Countries signatories of the Bologna Process not pertaining to the EU. Possibly for such reason the Recommendation carefully signals the existing relation with the QF-EHEA in what concerns post-secondary education (Table 2).

The Directive on Recognition of Professional Qualifications

The "Directive on Recognition of Professional Qualifications 2005/36" (European Union, 2005) is not a Framework in the full sense of the

Table 1. Clustering of qualifications descriptors in different frameworks

Bologna, QF-EHEA	EU, EQF-LLL	EUR-ACE
A. Knowledge and understanding B. Applying knowledge and understanding C. Making Judgments D. Communications skills E. Learning skills	1. Knowledge 2. Skills 3. Competences	I. Knowledge and understanding II. Engineering analysis III. Engineering design IV. Investigations V. Engineering practice VI. Transferable skills

Table 2. Relating levels of qualifications in different frameworks

Bologna, QF-EHEA	EU, EQF-LLL	EUR-ACE	EU Directive 2005/36
Short Cycles (ShC)	Level 5 (L5)		Art. 11 c)
First Cycles (FC)	Level 6 (L6)	First Cycles (FC)	Art. 11 d)
Second Cycles (SC)	Level 7 (L7)	Second Cycles (SC)	Art. 11 e)
Third Cycles (TC)	Level 8 (L8)		

term, but it has the force of law in the space of the European Union (while no such "European laws" can exist in the field of education, that according to the European Treaties is outside the EU competences).

The Directive aims at regulating this major issue of qualifications recognition in the EU space and focus on the post-secondary system, though not including the doctorate level. It makes a fundamental differentiation between those professions where some common platform of activities and required basic training are identified (the case of professions in the area of health and of architecture, that were up to 2005 the object of "special" Directives) and the other professions where no common platform of activity and requirements are identified. The former professions are subject of the Directive Annexes, whereas the latter fall within the general system for the recognition of qualifications. For this general system, in which Engineering is included, Article 11 defines five levels of qualification, of which three levels are associated to post-secondary education. These levels are coherent with and fit well in the overall qualifications structure adopted both by the QF-EHEA and the EQF-LLL, and also by EUR-ACE in the engineering area (see Table 2). A specific "Engineering Platform" is currently under discussion by initiative of professional associations from a number of countries within the FEANI umbrella.

The Directive is in the process of being implemented in all the EU countries. The Database of regulated professions in the EU Member States plus Iceland, Norway, Liechtenstein and Switzerland is also available (European Union, 2008b). Considering the close relation of the Directive and the Qualification Frameworks, it constitutes a major instrument to enforce the whole concept for recognition purposes.

Sectoral Frameworks

"Sectoral Frameworks" are concerned with specific discipline descriptors, grouped in scientific and technological areas, with direct relation to the different professions, and mostly directed to support quality assurance and recognition systems. To a large extent, Sectoral Frameworks represent "Bologna" in actual practice.

Sectoral Frameworks ideally result from wide transnational cooperation and agreements between stakeholders, namely Higher education institutions (EIs) and professional associations. They should naturally relate and be identified within the wide descriptors of the meta frameworks, but they quite clearly are more detailed in the descriptions.

A major concerted effort aiming at developing subject area frameworks has been the Tuning Project (2000). As written by its coordinators, it aimed at contributing to the elaboration of a framework of comparable and compatible qualifications in each of the (potential) signatory countries of the Bologna process, which should be described in terms of workload, level, learning outcomes, competences and profile. In its first phases (2000 - 2004), the Tuning project dealt with 9 subject areas (Business, Chemistry, Earth Sciences, Education, European Studies, History, Mathematics, Nursing and Physics).

The engineering area, for its nature, with its several branches and its different profiles (either more theoretically or more vocationally oriented), was the ground for a variety of

projects and proposals of sectoral frameworks during this decade:

(i) The EUR-ACE framework for accreditation of engineering programmes (ENAEE, 2008a);
(ii) The ABET (Accreditation Board for Engineering and Technology) criteria for accrediting Engineering Programmes (ABET, 2009);
(iii) Within the mentioned TUNING methodology, the proposals of the "Engineering Synergy Group" of the parallel E4 Thematic Network project (Augusti et al., 2003);
(iv) The first results of the quoted OECD AHELO initiative, published in May 2009 in collaboration with Tuning (Tuning Association, 2009; Wagenaar, 2010), i.e. a tentative "Conceptual Framework of Expected/Desired Learning Outcomes in Engineering", merging the LOs of the EUR-ACE first cycle and ABET criteria;
(v) The "Criteria for Academic Bachelor's and Master's Curricula", proposed by the three Dutch Technical Universities (Delft, Eindhoven, Twente) (Meijers et al., 2005);
(vi) The framework for engineering education proposed by the CDIO (Conceive-Design-Implement-Operate Real World) initiative (CDIO, 2002).

Depending on the sector of knowledge, sectoral frameworks may be further subdivided in sub-sectors characterized by specific descriptor, including, if applicable, the identification of professional activities for which the candidates are to be prepared. Engineering is a good example of a sector that requires specific domain descriptors, that can be differentiated according to the different specialties or "branches" (e.g. civil engineering, chemical engineering, etc.). This will be mentioned in the following sub-section.

Branch Level Descriptors

These characterize outcomes at branch level, including possibly main or core curricula contents and methods, which aim at giving substance to the higher level descriptors.

Significant work is taking place in Europe, at this lower but relevant level, namely through the activity of "Education Working Parties" of the relevant scientific-technical Associations, or through the initiative of higher education institutions. Generally, these initiatives include the 'translation' of sectoral descriptors into specific branch-level descriptor, the identification of core contents and the identification of scope, depth and breadth of the programmes, a major issue in the engineering area when comparing programmes. Five initiatives may serve as illustration:

(i) The Thematic Network directly related to the TUNING project, EUCEET II - European Civil Engineering Education and Training II, developed under the umbrella of the European Council of Civil Engineers (ECCENET, 2006), which led to the identification of both generic and specific competences that should be associated to civil engineering programmes.
(ii) The work of the Working Party on Education of the European Federation of Chemical Engineering, which led to Recommendations for Chemical Engineering Education in a Bologna Two Cycle Degree System (EFCE, 2005). Such recommendations cover *Learning Outcomes* and *How to Achieve the Learning Outcomes*, for both First and Second Cycle degrees. The core curriculum proposed covers about two thirds of the total, leaving space for significant modifications and innovations.
(iii) The CHEMPASS Project (Gagneur, 2009), an European project involving 13 HEIs, which aims at promoting mobility and attractiveness of European Chemical Engineering Higher Education through a thorough analysis of contents and methods, and through the development of tools for competence evaluation.
(iv) The VDI-Society for Chemical and Process Engineering Recommendation for the development of consecutive Bachelor-

Master degrees both for 'more applications oriented' and for 'more research oriented' profiles (VDI-GVC, 2008). The VDI-GVC recommendation defines: (i) professional profiles and aims for the courses, adopting the EUR-ACE Framework Standards; (ii) qualifications for admissions; (iii) structure of the degree course, including core curricula; (iv) fields of studies; and (v) industrial placements. This proposal is a major recognition of the relevance of the EUR-ACE outcomes and respective descriptors and represents a remarkable example on changes that promote recognition of qualifications.

(v) The initial work at branch level within the AHELO-Tuning project (2009), for first cycles in the branches of electrical, mechanical and civil engineering.

SECTORAL FRAMEWORKS IN THE ENGINEERING FIELD

Descriptors at all levels are all relevant for a truly effective QA system, but "Sectoral frameworks" are the most significant in the development of QA. It is therefore appropriate to focus on them.

Speaking specifically of the Engineering Sector, the previous section has identified a number of relevant initiatives, driven by different objectives, hence with somewhat different structures. Some more details follow here.

1. The EUR-ACE Framework for accreditation of engineering programmes (ENAEE, 2008a, 2008b; Augusti, 2007a, 2007b, 2009) aims at constituting a reference framework to ensure the suitability of programmes to serve as entry routes to the engineering profession.

The EUR-ACE framework includes guidelines for the criteria and requirements for programme assessment, indicating that at least the following items should be considered: (1) Needs, objectives and outcomes; (2) Educational Process; (3) Resources and Partnerships; (4) Assessment of the educational process; and (5) Management system.

In what concerns curriculum requirements and objectives, the EUR-ACE framework specifies 21 programme outcomes for 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

In (Feyo de Azevedo, 2009), the relation and compatibility of these outcomes with QH-EHEA and EQF-LLL have been demonstrated, together with a comparative synthesis of descriptors for the different outcomes and for the two qualifications levels.

The relevance of the EUR-ACE proposals both for Europe and in a global context have been confirmed by the fact that – as already noted - they have been taken together with the ABET criteria (cf. the following paragraph) as the basis for the First Cycle Programme Learning Outcomes in Engineering agreed in the framework of the AHELO feasibility study (Tuning Association, 2009).

2. The criteria for accrediting of Engineering Programmes adopted by ABET (Accreditation Board for Engineering and Technology) (ABET, 2009). ABET is a federation of 29 professional and technical societies of the United States of America. It runs a well established system that includes nine criteria for the accreditation of engineering programmes.

It should be noted that ABET has been developed within a context where, essentially, the first cycle (Bachelor) is the natural entry route to the profession. At present, hot discussions are developing for introducing some sort of "Second-cycle degrees" in the United States:

it is therefore of utmost and urgent interest to relate on the global scale the engineering recognition and accreditation systems of the Americas, Oceania and Asia with EUR-ACE and the European Frameworks.

Indeed work in this direction is in progress thanks to an agreement of collaboration between ENAEE and the International Engineering Alliance, that coordinates three "Accords" for the mutual recognition of degrees [Washington (1989), Sydney (2001) and Dublin (2002), respectively at the level of "Professional Engineers", "Engineering Technologists" and "Engineering Technicians"] and three "Professional Mobility Fora", such as; the APEC Engineer agreement, (1999), the Engineers Mobility Forum (2001) and the Engineering Technologist Mobility Forum (2003) (IEA-WA, 1989).

3. The CDIO (Conceive-Design-Implement-Operate Real World) initiative (CDIO, 2002), a framework for engineering education, is an initiative of three Swedish Technical Universities (Royal Institute of Technology - KTH, Linköping University, Chalmers University of Technology] and the Massachusetts Institute of Technology (MIT) in the US. As the CDIO coordinators describe (Berggren et al., 2003) "the Initiative's vision is to provide students with an education stressing engineering fundamentals set in the context of conceiving–designing–implementing–operating (CDIO) real–world systems and products". The CDIO requirements are summarized in 17 descriptors grouped in 4 "building blocks", that have been compared with the ABET requirements, finding a "strong correlation" in the great majority of cases, and "good correlation" in the others.
4. The very ambitious initiative recently started by the OECD Directorate for Education and denoted by the acronym AHELO (Assessment of Higher Education Learning Outcomes) has been already hinted: in a sense it intends to continues at the global scale the work of the "Tuning" project, with specific reference – at least in the initial phase – to first degrees in the sectors of engineering and economics.

The first outcome of this effort has been the already quoted "Tuning-AHELO Conceptual Framework of Expected/Desired Learning Outcomes in Engineering", published in May 2009 as the result of a comparative review between the EUR-ACE Framework Standards for the Accreditation of Engineering Programmes and the ABET criteria for accrediting engineering programmes, consistent also with a number of other frameworks / sets of Learning Outcomes, identified as being of relevance for defining the Tuning-AHELO Conceptual Framework for first cycle engineering programmes (a similar framework has been published for Economics). However, the successive developments of the initiative, that should include a "*Assessment Frameworks*" and indicate appropriate tests to measure the actual "learning outcomes" of last-year students, are *de facto* still in the planning stage because of financial difficulties.

CONCLUSION

The ongoing "Bologna Process", started in 1999, aims at creating in Europe "a system of easily readable and comparable degrees" in order to facilitate mobility of students' and graduates' and to promote attractive conditions for third countries to cooperate with European Universities. One of the great assets of Europe is the diversity of its cultures. The "Bologna Process" does not pursue the "uniformity" of the diverse educational systems that derive from such European cultural diversity and can only be harmonized by a spontaneous convergence in the long run.

Mutual trust is key for achieving the essential goals of the Bologna Process. To create such trust it is necessary to build transparent and readable academic curricula and professional qualifications. This is achieved through transparent Qualifications Frameworks (QF) and

Quality Assurance procedures (QA), recognised and accepted by all partners and stakeholders.

It is today clear that only "Field-specific" QF and QA approaches can give concrete application and put on solid and practical grounds the "Bologna" objectives.

This paper has tackled these interrelated issues of QF and QA, with particular emphasis on engineering education, and discussed its "accreditation" as entry route for the profession. Several relevant examples of on-going initiatives in designing "Sectoral Frameworks" and "Field-specific" quality assurance methodologies have been critically described. The attention has been focussed on Europe, but global initiatives, such as, AHELO and OECD projects as well as the collaboration between ENAEE and IEA have also been cited in the paper.

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ENDNOTES

1 Note also that in many countries the word "accreditation" (or a similar-sounding one) has a "legal" value and is reserved to the use of governmental (or para-governmental) authorities. In these cases, different terms can be and are being used to indicate what in this paper is referred to as "pre-professional accreditation" (or simply "accreditation").

2 ACE, ECTNA, ENAEE, EQANIE, SEFI (see Appendix)

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APPENDIX: ACRONYMS

ABET – Accreditation Board for Engineering and Technology
ACE - Association Européenne des Conservatoires
AHELO – Assessment of Higher Education Learning Outcomes
ASIIN - Fachakkreditierungsagentur für Studiengänge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften und der Mathematik / Accreditation Agency for Study Programs in Engineering, Informatics, Natural Sciences and Mathematics
CDIO – Conceive-Design-Implement-Operate
ECTNA - European Chemistry Thematic Network Association
ECTS – European Credit Transfer and Accumulation System
EHEA – European Higher Education Area
ENAEE - European Network for Accreditation of Engineering Education
ENQA - European Association for Quality Assurance in Higher Education
EQANIE - European Quality Network for Informatics Education
EQF-LLL – European Qualifications Frameworks for Lifelong Learning
ESG – European Standard and Guidelines for Quality Assurance in the European Higher Education Area
EUR-ACE – European Accreditation of Engineering Education
EURO-INF – European Informatics Project
HE – Higher Education
HEI - Higher Education Institutions (Universities and comparable Institutions)
IEA - International Engineering Alliance
LO – Learning Outcomes
OECD - Organisation for Economic Co-operation and Development (OCSE in Latin languages)
QA – Quality Assurance
QF – Qualifications Framework
QF-EHEA – Qualifications Framework for the European Higher Education Area
SEFI - Société Européenne pour la Formation d'Ingénieurs / European Society for Engineering Education
TU-3 – Technical Universities 3 (the Dutch Association of Technical Universities)
WFME – World Federation of Medical Education