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High Level Qualifications Frameworks and the EUR-ACE Frameworks Standards – do they fit together?

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Executive Summary

Two key political, academic and economical issues in the prevailing scenario of this contemporaneous global World are those of transnational co-operation and mobility of students and professionals. Co-operation and mobility require academic and professional recognition. Recognition requires TRUST. Trust requires transparency and readability of academic curricula and professional qualifications. Such is achieved through transparent qualifications frameworks and quality assurance procedures, recognised and accepted by all partners and stakeholders. In this context, an immense reform is taking place in Europe, under the codename *Bologna Process*, involving some 16 million students and well over 5600 institutions of 46 countries. The commitment is the creation of the European Higher Education Area, an essential step for preparing Europe for this current paradigm of 'coopetition' in the World.

Qualifications frameworks may be seen, and are being developed, at three major levels of descriptors, viz. – (i) High level descriptor of competences, of a general nature, describing global qualifications associated to degrees; (ii) Sectoral descriptors grouped in scientific and technological areas, with direct relations to the professions; and (iii) Contents descriptors, characterizing main or core curricula contents and methods. In parallel, but complementary, legislation has been approved within the European Union, the Directive on recognition of professional qualifications, which constitutes the legal framework for recognition and professional mobility.

In these notes and in the lecture I shall: (i) introduce some relevant issues of the Bologna Process, for the purpose of this work; (ii) analyze the main characteristics of the existing frameworks and related descriptors, at the three levels identified; and (iii) in particular, discuss how such frameworks articulate between each other.

As expected, EUR-ACE and other sectoral frameworks have higher levels of details, when compared with the high level meta frameworks. The comparison or correlation between different frameworks, which were built in different contexts and with different objectives in mind, is for sure not straightforward, in some cases even slightly fuzzy, but, from the analysis it emerges that EUR-ACE relates well with such frameworks.

The conclusion is – Yes, EUR-ACE and the Meta Frameworks fit together.

Keywords: 'Coopetition', Bologna Process, Recognition, Qualifications Frameworks, Quality Assurance

1. **Introduction -** Key issues in the Global World

Two key political, academic and economical issues in the prevailing scenario of the contemporaneous global World are those of transnational co-operation and mobility of students and professionals. Co-operation and mobility require academic and professional recognition. Such recognition requires TRUST. Trust requires transparency and readability of academic curricula and professional qualifications. Such is achieved through transparent qualifications frameworks and quality assurance procedures recognised and accepted by all partners and stakeholders.

With the historical background of progress in science and technology, and of societal and political changes that occurred on the last quarter of the 20th Century, an immense reform is taking place in Europe, under the codename Bologna Process[1], involving some 16 million students and well over 5600 institutions of 46 countries. The commitment is the creation of the European Area of Knowledge, with its two main pillars, the European Higher Education Area (EHEA) and the European Research Area (ERA), aiming at creating a competitive economy based on a knowledge society, an essential step for preparing Europe for this current paradigm of 'coopetition' in the World.

In what concerns the European Higher Education Area, the Bologna Process should thus be seen on a dual environment of related and complementary, but different, academic and political 'expected outcomes': (i) the restructuring of the offer of higher education, including the necessary mechanisms and tools to promote trust and induce co-operation, leading to a more attractive offer, in a global context, nearer to the needs and interests of Society; and (ii) an evolution of teaching/learning paradigms, adapted to the concepts and perspectives of the modern society and to the available technical tools, within a concept of lifelong learning.

2. Qualifications Frameworks – what they are and how they relate between each other

2.1. An open wide view of Qualifications Frameworks[2]

Strictus sensus a Qualifications Framework (QF) is, essentially, a systematic description of an education system, expressing the expected learning outcomes for a given qualification, that is expressing what a learner is expected to know, understand and be able to do after successful completion of a process of learning.

A QF should describe all the qualifications in a higher education system, or in an entire education system if the framework is developed for this purpose. It also shows how the various qualifications in the education or higher education system articulate and how learners can move between qualifications. QF thus focus mainly on outcomes and on the several learning paths, including those of lifelong learning, that may lead to a given qualification.

QF based on Learning Outcomes (LO) 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

[1] Full information concerning the Bologna Process is compiled and available in the site of the Bologna Follow-up Group (BFUG) Secretariat, at http://www.ond.vlaanderen.be/hogeronderwijs/bologna/

[2] The issue of QF is dealt with in a large number of reports. The Author took most of the concepts from two main sources – QF-EHEA (2005) and Bergan (2007)

recognition of qualifications, by all stakeholders; and (iii) as a pre-requirement, in the implementation of Quality Assurance systems.

Indeed, quality assurance systems should include clear and measurable objectives and standards, hence there can be no 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.

For such purpose, an open wide view of the concept of QF (QF in *lactus sensus*) should be adopted. QF unfold and are being developed at three major levels of descriptors, related to and characterized by different levels of detail, viz. - (i) The meta frameworks, including high level descriptors of competences, of a general nature, describing global qualifications associated to degrees; (ii) The sectoral frameworks, including sectoral descriptors grouped in scientific and technological areas, with direct relations to the different professions, and mostly directed to support quality assurance and recognition systems; and (iii) Contents descriptors, characterizing main or core curricula contents and methods, which aim at giving substance to the higher level descriptors.

It should be added that in parallel, but complementary, legislation has been approved within the European Union, the Directive on Recognition of Professional Qualifications (Directive, 2005), which though not being a QF in the sense presented above, constitutes the legal framework for recognition and professional mobility. This Directive is expected to play a major role for such purpose, in years to come. The Directive will be discussed below, jointly with the existing frameworks.

2.2. Qualifications Frameworks and descriptors at different levels of detail

The key documents for the present work are (i) the Qualifications Framework for the construction of the European Higher Education Area, directly related to the Bologna Process (QF-EHEA, 2005); (ii) the European Qualifications Framework for Lifelong Learning, developed within the European Union (EQF-LLL, 2008); (iii) The EU Directive on Recognition of Professional Qualifications (Directive, 2005); and (iv) the EUR-ACE Framework Standards for the Accreditation of Engineering Programmes (EUR-ACE, 2006).

The discussion to come in this and the next sections will focus on these documents, but further includes comments concerning other frameworks (than EUR-ACE) in the engineering sector, and also includes comments to initiatives that aim at bringing in substance to the qualifications frameworks, namely through the identification of core contents and the identification of scope, depth and breadth of the programmes at specialty level.

The information compiled for the analysis is organized in the following nine Tables:

Table 1 – Identification of clusters of descriptors in different frameworks, including the identification of the EUR-ACE building blocks;

Table 2 – Identification of and relation between levels of qualification in different frameworks, including EUR-ACE and the European Directive for Recognition of Professional Qualifications – Directive 2005/36/EC;

Table 3 - Presentation of descriptors for Short Cycles (or equivalent) qualifications of European Frameworks;

Table 4 - Presentation of descriptors for First Cycle (or equivalent) qualifications of European Frameworks, including the EUR-ACE building blocks;

Table 5 - Presentation of descriptors for Second Cycle (or equivalent) qualifications of European Frameworks, including the EUR-ACE building blocks;

Table 6 – ABET Criterion 3 – Students Outcomes;

Table 7 – Building Blocks of the CDIO Syllabus and correlation with ABET;

Table 8 - European Directive 2005/36/EC – The relevant article 11;

Table 9 – Recommendations of the European Federation of Chemical Engineering of Outcomes and Methods for First and Second Cycle Degrees in Chemical Engineering

It should be advanced that the organization chosen for Tables 2 to 5 reflects the existing relations between the meta frameworks, the EUR-ACE framework and the Directive.

2.2.1. Meta Qualifications Frameworks and related high level descriptors.

These characterize high level groups of qualifications. They are generally developed at institutional level of governments and stakeholders. They may differ in background and objectives. As such, different frameworks may arise (have arisen), employing different sets of descriptors, or grouping such descriptors in different clusters of outcomes.

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, 2005), approved by the 46 signatory countries of the Bologna Process.

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. Tables 3 to 5 detail the descriptors for each of the respective levels.

(ii) The European Qualifications Framework for Lifelong Learning (EQF-LLL, 2008), a Recommendation of the European Parliament and of the Council, approved on April 23, 2008.

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 and detailed in Tables 3, 4 and 5.

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).

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)		

2.2.2. *Sectoral Frameworks*.

Sectoral frameworks are concerned with specific discipline descriptors and ideally result from wide transnational co-operation and agreements between stakeholders, namely higher education institutions and professional associations. Sectoral frameworks should naturally relate to and be identified within the wide descriptors of the meta frameworks, but they quite clearly are expected to be more detailed in the descriptions. Depending on the sector of knowledge, they may be further subdivided in sub-sectors characterized by specific domain descriptors, 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, related to the different specialties.

A major concerted effort aiming at developing subject area frameworks is the TUNING Project (TUNING, 2000). As written by its coordinators, it aims 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. An example of the relevance of TUNING will be given in section 2.2.4. below.

Speaking of the wide Engineering Sector, we can identify a number of relevant initiatives, again driven by different objectives, hence with somewhat different structures:

(i) The EUR-ACE framework for accreditation of engineering programmes (EUR-ACE, 2006a, 2006b; Augusti 2007a, 2007b, 2009), which to a large extent was influenced by TUNING, aims at

constituting a reference framework to ensure the suitability of programmes to serve as entry routes to the engineering profession.

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

In what concerns curriculum requirements and objectives, EUR-ACE is built around the six Programme Outcomes identified in Table 1 and relates, at high level, to the QH-EHEA and to the EQF-LLL, as presented in Table 2. Details of descriptors for the different outcomes and for the two qualifications levels are provided in Tables 4 and 5. It is quite clearly a major proposal both for Europe and in a global context.

(ii) The ABET (Accreditation Board for Engineering and Technology) criteria for accrediting of Engineering Programmes (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. The descriptors for criterion 3 – program outcomes - are presented in Table 6.

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. For all global reasons, it is of utmost interest to relate this system with EUR-ACE and with the European Frameworks (and indeed this can be done and has been done), but the presentation of such analysis is out of the scope of the present work.

(iii) The CDIO (Conceive-Design-Implement-Operate Real World) initiative (CDIO, 2002), a framework for engineering education.

CDIO is an initiative of the Royal Institute of Technology (KTH), Linköping University, and Chalmers University of Technology, of Sweden, and of the Massachusetts Institute of Technology of 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'.

CDIO is made of 12 standards, including the CDIO Syllabus shown in Table 7. The correlation with ABET requirements shown in the Table is provided by the CDIO working group itself.

The same comment made to ABET applies. The context of development of CDIO is somehow different from that of the QF-EHEA and of EUR-ACE and as such it is out of the scope of the present study to discuss further this framework.

2.2.3. The Directive on Recognition of Professional Qualifications

The Directive is not a Framework in the through sense of the term, but it has the force of law in the space of the European Union (Directive, 2005). It 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.

The Directive 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) 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, where Engineering is included, Article 11 defines five levels of qualification, of which three levels are associated to post-secondary education (Table 8). 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 (Table 2).

It should be finally stressed that the Directive is right now in the process of being implemented in the EU space. The Database of regulated professions in the EU Member States, Iceland, Norway, Liechtenstein and Switzerland is now available for consultation (EU, 2008). Considering the close relation of the Directive and the QF discussed, it constitutes a major instrument to enforce the whole concept for recognition purposes.

2.2.4. Descriptors at syllabus (contents) level - core curricula.

Significant work is taking place in Europe, at this lower, but relevant level, namely through the activity of Education Working Parties, or through the initiative of higher education institutions. Generally, these initiatives aim at bringing in substance to the qualifications, namely through 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. Four initiatives 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 hgeneric 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. As a good case study and illustration of this effort for defining and giving substance to qualifications at the level of specific domains, Table 9 presents the recommendations for both first and second cycle qualifications, including those of transferable skills.

(iii) The CHEMPASS Project (Gagneur, 2009), an European project involving 13 Higher Education Institutions, 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 recommendation characterizes – (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.

Table 3 – Comparison of descriptors – QF-EHEA Short Cycles and EQF-LLL - Level 5

Bologna, QF –EHEA Short Cycles	**EU, EQF-LLL Level 5**
ShC-A. Have demonstrated knowledge and understanding in a field of study that builds upon general secondary education and is typically at a level supported by advanced textbooks; such knowledge provides an underpinning for a field of work or vocation, personal development, and further studies to complete the first cycle; **ShC-B.** Can apply their knowledge and understanding in occupational contexts; **ShC-C.** Have the ability to identify and use data to formulate responses to well-defined concrete and abstract problems; **ShC-D.** Can communicate about their understanding, skills and activities, with peers, supervisors and clients; **ShC-E.** Have the learning skills to undertake further studies with some autonomy.	**L5.1.** Comprehensive, specialized, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge. **L5.2.** A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems **L5.3.1.** Exercise management and supervision in contexts of work or study activities where there is unpredictable change; **L5.3.2.** Review and develop performance of self and others.

Table 4 – Comparison of descriptors –
QF-EHEA First Cycles, EQF-LLL - Level 6 and EUR-ACE First Cycles

Bologna, QF-EHEA, First Cycles	EU, EQF-LLL, Level 6	EUR-ACE, First Cycles
FC-A. Have demonstrated knowledge and understanding in a field of study that builds upon their general secondary education, and is typically at a level that, whilst supported by advanced textbooks, includes some aspects that will be informed by knowledge of the forefront of their field of study **FC-B.** Can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study **FC-C.** Have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical issues **FC-D.** Can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences **FC-E.** Have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy.	**L6.1.** Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles; **L6.2.** Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialized field of work or study **L6.3.1.** Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts **L6.3.2.** Take responsibility for managing professional development of individuals and groups	**FC-I.1.** Knowledge and understanding of the scientific and mathematical principles underlying their branch of engineering; **FC-I.2.** A systematic understanding of the key aspects and concepts of their branch of engineering; **FC-I.3.** Coherent knowledge of their branch of engineering including some at the forefront of the branch; **FC-I.4.** Awareness of the wider multidisciplinary context of engineering. **FC-II.1.** The ability to apply their knowledge and understanding to identify, formulate and solve engineering problems using established methods; **FC-II.2.** The ability to apply their knowledge and understanding to analyse engineering products, processes and methods; **FC-II.3.**the ability to select and apply relevant analytic and modeling methods. **FC-III.1.** The ability to apply their knowledge and understanding to develop and realize designs to meet defined and specified requirements; **FC-III.2.** An understanding of design methodologies, and an ability to use them. **FC-IV.1.** The ability to conduct searches of literature, and to use data bases and other sources of information; **FC-IV.2.** The ability to design and conduct appropriate experiments, interpret the data and draw conclusions; **FC-IV.3.** Workshop and laboratory skills. **FC-V.1.** The ability to select and use appropriate equipment, tools and methods; **FC-V.2**. The ability to combine theory and practice to solve engineering problems; **FC-V.3.** An understanding of applicable techniques and methods, and of their limitations; **FC-V.4.** An awareness of the non-technical implications of engineering practice. **FC-VI.1.** Function effectively as an individual and as a member of a team; **FC-VI.2.** Use diverse methods to communicate effectively with the engineering community and with society at large; **FC-VI.3.** Demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice; **FC-VI.4.** Demonstrate an awareness of project management and business practices, such as risk and change management, and understand their limitations; **FC-VI.5.** Recognize the need for, and have the ability to engage in independent, life-long learning.

Table 5 – Comparison of descriptors -
QF-EHEA Second Cycles, EQF-LLL - Level 7 and EUR-ACE Second Cycles

Bologna, QF-EHEA, Second Cycles	EU, EQF-LLL, Level 7	EUR-ACE, Second Cycles
SC-A. Have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within a research context; **SC-B.** Can apply their knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study; **SC-C.** Have the ability to integrate knowledge and handle complexity, and formulate judgments with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments; **SC-D.** Can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non specialist audiences clearly and unambiguously; **SC-E.** Have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous.	**L7.1.1.** Highly specialized knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research; **L7.1.2.** Critical awareness of knowledge issues in a field and at the interface between different fields. **L7.2.** Specialized problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields. **L7.3.1.** Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; **L7.3.2.** Take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams;	**SC-I.1.** An in-depth knowledge and understanding of the principles of their branch of engineering; **SC-I.2.** A critical awareness of the forefront of their branch. **SC-II.1.** The ability to solve problems that are unfamiliar, incompletely defined, and have competing specifications; **SC-II.2.** The ability to formulate and solve problems in new and emerging areas of their specialization; **SC-II.3.** The ability to use their knowledge and understanding to conceptualize engineering models, systems and processes; **SC-II.4.** The ability to apply innovative methods in problem solving. **SC-III.1.** An ability to use their knowledge and understanding to design solutions to unfamiliar problems, possibly involving other disciplines; **SC-III.2.** An ability to use creativity to develop new and original ideas and methods; **SC-III.3.** An ability to use their engineering judgment to work with complexity, technical uncertainty and incomplete information. **SC-IV.1.** The ability to identify, locate and obtain required data; **SC-IV.2.** The ability to design and conduct analytic, modelling and experimental investigations; **SC-IV.3.** The ability to critically evaluate data and draw conclusions; **SC-IV.4.** The ability to investigate the application of new and emerging technologies in their branch of engineering. **SC-V.1.** The ability to integrate knowledge from different branches, and handle complexity; **SC-SC-V.2.** A comprehensive understanding of applicable techniques and methods, and of their limitations; **SC-V.3.** A knowledge of the non-technical implications of engineering practice. **SC-VI.1.** Fulfill all the Transferable Skill requirements of a First Cycle graduate at the more demanding level of Second Cycle; **SC-VI.2.** Function effectively as leader of a team that may be composed of different disciplines and levels; **SC-VI.3.** Work and communicate effectively in national and international contexts.

Table 6 – ABET Criteria (ABET 2009) - Criterion 3 – Student Outcomes*

(a)	an ability to apply knowledge of mathematics, science, and engineering
(b)	an ability to design and conduct experiments, as well as to analyze and interpret data
(c)	an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d)	an ability to function on multidisciplinary teams
(e)	an ability to identify, formulate, and solve engineering problems
(f)	an understanding of professional and ethical responsibility
(g)	an ability to communicate effectively
(h)	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i)	a recognition of the need for, and an ability to engage in life-long learning
(j)	a knowledge of contemporary issues
(k)	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

* Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

Table 7 – CDIO Framework* and correlation with the ABET requirements

	Building Blocks of the CDIO Syllabus	***Details of CDIO descriptors***	***Correlation with ABET requirements****
1.	Technical knowledge and reasoning	1.1. Knowledge of underlying sciences	SC with (a)
		1.2. Core engineering fundamental knowledge	SC with (a) GC with (a)
		1.3. Advanced engineering fundamental knowledge	
2.	Personal and professional skills and attributes	2.1. Engineering reasoning and problem solving	SC with (e) SC with (b)
		2.2. Experimentation and knowledge discovery	GC with (c) SC with (i)
		2.3. System thinking	SC with (k)
		2.4. Personal skills and attitudes	
		2.5. Professional skills and attitudes	
3.	Interpersonal skills: Teamwork and communication	3.1. Teamwork	SC with (f)
		3.2. Communications	SC with (g)
		3.3. Communications in foreign languages	SC with (g)
4.	Conceiving, Designing, Implementing and Operating systems in the enterprise and societal context	4.1. External and societal context	SC with (h) and (j)
		4.2. Enterprise and business context	
		4.3. Conceiving and engineering systems	SC with (c)
		4.4. Designing	SC with (c)
		4.5. Implementing	SC with (c)
		4.6. Operating	SC with (c)

* In (CDIO, 2001); ** SC – Strong Correlation with ABET () ; GC – Good Correlation with ABET ()

Table 8 - European Directive 2005/36/EC – Article 11 (Directive, 2005)

Art. 11 (c) A diploma certifying successful completion of

(i) either training at post-secondary level other than that referred to in points (d) and (e) of a duration of at least one year or of an equivalent duration on a part-time basis, one of the conditions of entry of which is, as a general rule, the successful completion of the secondary course required to obtain entry to university or higher education or the completion of equivalent school education of the second secondary level, as well as the professional training which may be required in addition to that post-secondary course;

(ii) or, in the case of a regulated profession, training with a special structure, included in Annex II, equivalent to the level of training provided for under (i), which provides a comparable professional standard and which prepares the trainee for a comparable level of responsibilities and functions. The list in Annex II may be amended in accordance with the procedure referred to in Article 58(2) in order to take account of training which meets the requirements provided for in the previous sentence;

Art. 11 (d) A diploma certifying successful completion of training at post-secondary level of at least three and not more than four years' duration, or of an equivalent duration on a part-time basis, at a university or establishment of higher education or another establishment providing the same level of training, as well as the professional training which may be required in addition to that post-secondary course;

Art. 11 (e) A diploma certifying that the holder has successfully completed a post-secondary course of at least four years' duration, or of an equivalent duration on a part-time basis, at a university or establishment of higher education or another establishment of equivalent level and, where appropriate, that he has successfully completed the professional training required in addition to the post-secondary course.

2.3. A note on organization of the engineering profession and education systems

The two levels of education primarily identified as 'higher education for the professions' are the First and Second Cycles of the QF-EHEA that correspond to Levels 6 and 7 of the EQF-LLL (Table 2).

Before proceeding with the final comments on comparing EUR-ACE with the meta qualifications frameworks, it is relevant to revisit and comment the diversity of organization of studies adopted in the European countries, linking such offer of education to the requirements of the engineering profession.

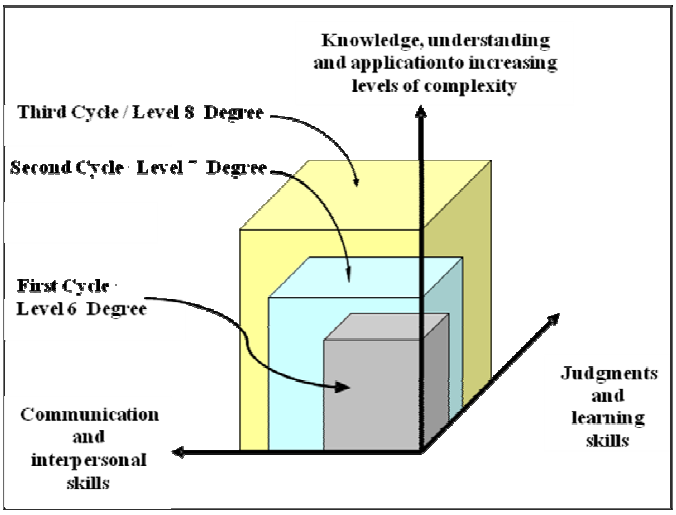

Fig. 1 – Expected Progression in Learning Outcomes along the degree system

Fig. 1 presents the 'wishful thinking' of a degree system designed for maximizing employability potential of First Cycle graduates. This is generally the concept that presides to the QF-EHEA. First Cycles contain essential all the basic desired learning outcomes relevant to the professions, these being enlarged and matured from cycle to cycle.

In engineering, a scientific but also technical domain where a binary system of education makes sense and exists in several countries, the discussion has been significant, in recent years, about

levels and profiles of required education in engineering, namely on the type of First Degrees that should be awarded by Higher Education Institutions. Such discussion took mainly place within the FEANI[3] and also within the CLAIU[4], between 2002 and 2005, prior to the approval of the Directive for Recognition of Professional Qualifications.

Though not all Countries share the same views, it is today recognized that two levels of engineering education and two main types of degree profiles, relevant to the profession, are available in the European countries, in possible trajectories as illustrated in Fig. 2.

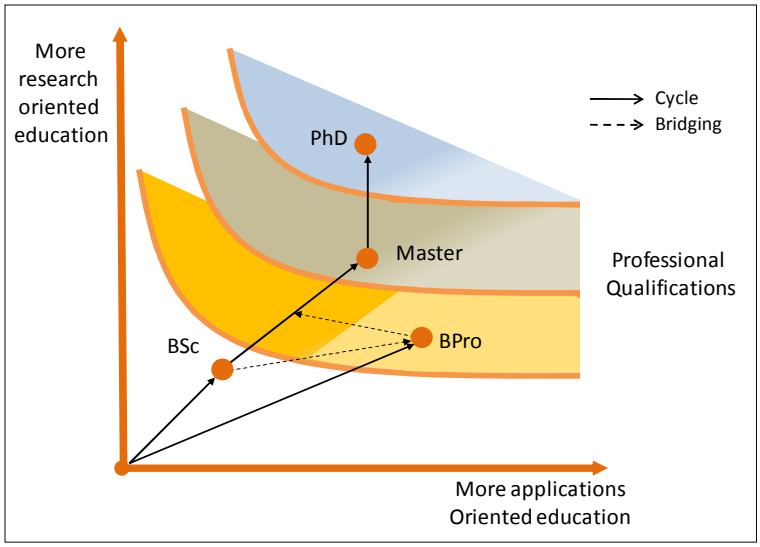

Fig. 2 - Different profiles for engineering education, assuming professional vs. academic first cycle degrees;

The levels are directly related to the expected qualifications of the professionals and to the expected engineering activity, both evaluated in direct relation to relevant technical, scientific and social aspects, such as having: (i) social responsibility (namely signing of projects, of which those in structural engineering are possibly the most relevant); (ii) recognised capacity to tackle large, complex problems; (iii) capacity to adapt to new jobs of high complexity and responsibility; (iv) capacity for effective activity in the production line; and, not the least, (v) the right attitude to use knowledge and skills in a given situation.

Programme outcomes should be evaluated against such criteria, thinking of the programme as entry route for the profession at one of the recognized levels.

Profiles have much to do with the background of Staff and the mission of the Institutions, ranging between theoretically oriented and applications oriented profiles. The set of recommendations of the VDI--Society for Chemical and Process Engineering (VDI-GVC, 2008) represent an excellent example of this type of distinction in the offer of engineering programmes

Still concerning differentiation, it is clear that differences in outcomes for First and Second Cycle Degrees are often related with scope, depth and breadth, which is in line with the suggested progression along the degree system depicted in Fig. 1.

[3] FEANI - Fédération Européenne d'Associations Nationales d'Ingénieurs, www.feani.org

[4] CLAIU - Council of Association of Long Cycle Engineers of a University or higher School of Engineering of the European Union, www.claiu.org

Another relevant perspective was advanced, from the very beginning of the Bologna reforms, by Research Universities, namely those that are part of CESAER[5]. They have argued that First Cycles of the more theoretically oriented profiles that characterize the education offer of Research Universities would not, or would not necessarily, lead to qualifications recognised as entry routes to the profession. Such is represented in Fig. 2, with the B.Sc. degree out of the professional qualifications area.

Finally, a number of relevant issues should be made and left clear:

(i) In the engineering profession, qualifications for a significant number of activities require accumulated long training at higher education level. In most countries this means the equivalent to 300 ECTS, but it is known that this is not the generalized situation.

(ii) What is in discussion is whether such education should be achieved through long cycle degrees, or if it can be achieved through accumulated two-cycle studies. The question of the type of offer is more and more a political issue, of educational policies, and in fact virtually all countries are adopting the two-cycle system, independently of the qualifications associated to First Cycle degrees.

(iii) What is also relevant is that the education systems include some form of communication between profiles that may lead to conversion or continuation of studies - that is to flexible study paths. This type of flexible scheme of education, also depicted in Fig. 2, is in place in several countries.

(iv) From the point of view of a framework for evaluating the programmes as entry routes for the profession, it is clear that there should be only one set of standards for First Cycle degrees and one set of standards for Second Cycle degrees, against which the degree programmes should be evaluated. This is indeed the concept adopted in the EUR-ACE system.

(v) Still with EUR-ACE, though the programme outcomes and accreditation criteria outlined in the *EUR-ACE Framework Standards* have been designed to be applied to the accreditation of the two main cycles defined in the Bologna Declaration, the use of programme outcomes makes these *Standards* applicable also to the accreditation of programmes leading directly to a degree equivalent to a Second Cycle Degree (conventionally termed 'Integrated Programmes'), that are still part of the European engineering education system (see EUR-ACE 2006b for further details).

2.4. Qualifications Frameworks – do they fit together?

So, finally the question of how do all these frameworks articulate?

Inspection of Tables 4 and 5 indicate that, as expected and perceivable, the descriptors for the sectoral framework (EUR-ACE) are significantly more detailed than those of the meta frameworks.

Figs. 3 and 4 were constructed from the analysis of descriptors presented in those Tables and put in evidence that it is possible to relate the different descriptors adopted.

[5] CESAER - the Conference of European Schools for Advanced Engineering Education and Research, www.cesaer.or (active on January 12, 2009).

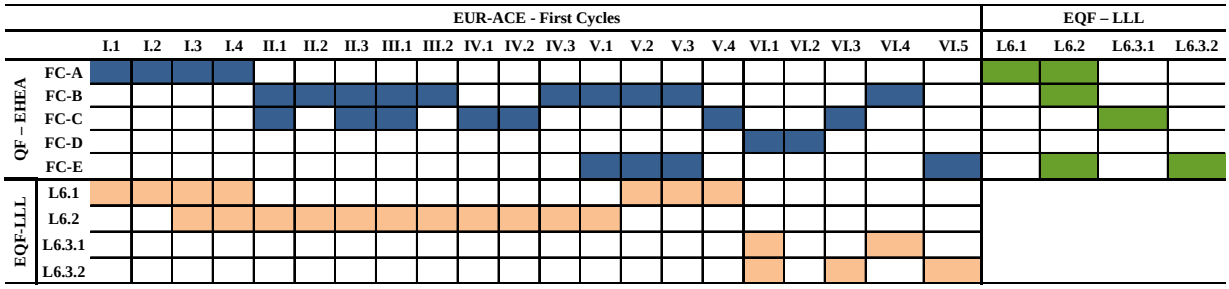

Fig. 3 – Relation between framework descriptors for First Cycle degrees (EQF-LLL - Level 6)

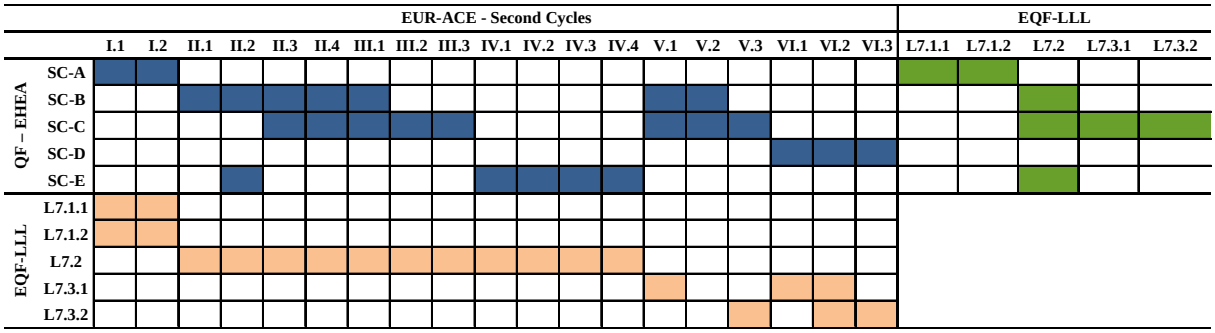

Fig. 4 – Relation between framework descriptors for Second Cycle degrees (EQF-LLL - Level 7)

It is true that the relations proposed have some degree of subjectivity. The descriptions of qualifications in the Tables are in some cases possibly too concise, leading to some fuzzy interpretations.

It should be noted in particular that the EQF-LLL adopts very concise, but broad descriptions, raising special difficulties in finding those relations. In particular it omits reference to personal and inter-personal skills, something that would not be expected.

Globally, however, it is clear that EUR-ACE finds good correspondence with both the QF-EHEA and the EQF-LLL.

Equally, but for some of the interpersonal skills, the QF-EHEA and the EQF-LLL find suitable correlation between their outcomes

3. Conclusions

QF based on Learning Outcomes (LO) represent a cornerstone of the reforms proposed within the Bologna Process - it plays 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 Systems.

Concerning the latter, indeed Quality Assurance Systems (internal systems, verified by external systems) should include clear and measurable objectives and standards, defined in terms of expected learning outcomes. These should constitute the basis for the required internal and external procedures of approval, monitoring and periodic review of programmes and awards, as stated in the Standards and Guidelines for Quality Assurance in the EHEA (SGQA, 2005) approved in

the Bergen Ministerial Bologna Conference of May 2005. This leads to say that there can be no quality assurance without an accepted qualifications framework.

In the paper, I have presented and discussed QF in *lactus sensus*, at three major levels of descriptors, related to and characterized by different levels of detail, viz. - (i) Meta frameworks, including high level descriptors of competences, of a general nature, describing global qualifications associated to degrees; (ii) Sectoral frameworks, including sectoral descriptors grouped in scientific and technological areas, with direct relations to the different professions, and mostly directed to support quality assurance and recognition systems; and (iii) Contents descriptors, characterizing main or core curricula contents and methods, which aim at giving substance to the higher level descriptors.

EUR-ACE represents a major contribution for the required quality assurance procedures that constitutes a backbone of all the recognition issues. The framework standards are based in detailed outcomes that seem to characterize well the main qualifications of academic programmes for the engineering profession.

As required by the European agreements of the Bologna Process, EUR-ACE relates well with the high level descriptors of the QF-EHEA. It relates equally well with the EQF-LLL, though not so clearly in the sub-set of outcomes concerning communication and other interpersonal skills.

A good indication of acceptance of these standards is the fact that it is being adopted by major Associations of European countries in the proposal of national frameworks at specialty level.

Globally, transparent sets of recommendations, at national, international, global, sectoral or syllabus level, are emerging in a coherent way.

So, the answer to the starting question is Yes. EUR-ACE fits well both 'up and downstream': upstream, its descriptors are seen as within or closely related to the descriptors of the meta frameworks of the European space; downstream, its outcomes are being employed at specialty level as qualification frames for degree courses.

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