Toward Global Recognition of Engineering Qualifications Accredited in Different Systems

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Summary
Globalisation of economic activity leads to the provision of engineering services across borders. Mechanisms for recognizing educational qualifications and professional standing have developed and have considerable scope for expansion. This paper examines the issues and approaches to developing recognition mechanisms between existing benchmarking and mutual recognition systems. A set of principles for comparing systems is proposed. In particular, the concept of substantial equivalence of the graduates of different systems rather that exact compliance to a standard should be used. Two systems, namely the IEA Accords and the EUR-ACE System, are used as examples of established standards and recognition mechanisms. Considerable commonality is identified as well as areas of further exploration.

1. Introduction

Globalization of economic activity is a reality that impacts on engineering professionals. Provision of commodities, goods, services and infrastructure increasingly involves engineering professionals and enterprises working across national boundaries. The quality of engineering professional practice and education is an essential facilitator of global practice. Mechanisms for easing the recognition of engineering qualifications accredited in one jurisdictions by authorities in another have therefore developed, either on a regional basis, for example the EUR-ACE system (Augusti, 2009), or without regional constraints, for example the International Engineering Alliance (IEA) educational accords, namely the Washington, Sydney and Dublin Accords (Hanrahan, 2009). In the case of EUR-ACE, an objective is to support European Union professional mobility mechanisms. Mutual recognition within each IEA Accord operates among the signatories of each accord. While there is some overlapping membership of the two systems, there is at present no recognition mechanism between these systems. Other regions have common standards or accreditation systems which may in future seek inter-system recognition. Cross-border recognition of accredited engineering qualifications is generally restricted to parties within each system. Working toward inter-system recognition is a logical progression in view of the globalization of engineering practice.

Global benchmarking and recognition of engineering qualifications is not a trivial operation. Considerable experience exists in convergence of national standards and accreditation systems into those of multi-national mutual recognition systems. It is therefore logical to build on this experience when progressing toward inter-system recognition. This paper is a collegial exploration of the principles and approaches for progressing to greater global recognition of graduates of accredited programmes from different systems. It also identifies common ground that exists and the need to accommodate differences.

Section 2 sets the context for the discussion by presenting a reference model for engineering professional formation. Section 3 reviews the salient features of IEA Accords and EUR-ACE system. Arising from this review, Section 4 establishes the principles that inform the development of inter-system benchmarking and mutual recognition. The common features of graduate attributes or programme outcomes are identified in Section 5. Features that occur in both systems are identified. The common attributes are confirmed by a widely accepted approach to curriculum design. We then propose possible approaches to going forward.

2. Setting the Context

We first set the context for the discussion of comparing academic and professional standards and educational achievement. The formation of an engineering professional, from entering higher education to being competent to practise independently, inevitably has two phases shown in Figure 1. A higher education programme (or set of related programmes) is the first component; this is consistent with engineering being a knowledge-intensive discipline. Engineering, while based on science is rooted in the real world that abounds with practices, risks, constraints, uncertainties, economic factors and human needs. The second component of formation is therefore training and experience in the engineering workplace. While in some systems the graduate may acquire a professional title immediately, further training and experience is generally required before adequate competence for independent practice is attained; graduates work under supervision until judged competent to practice independently.

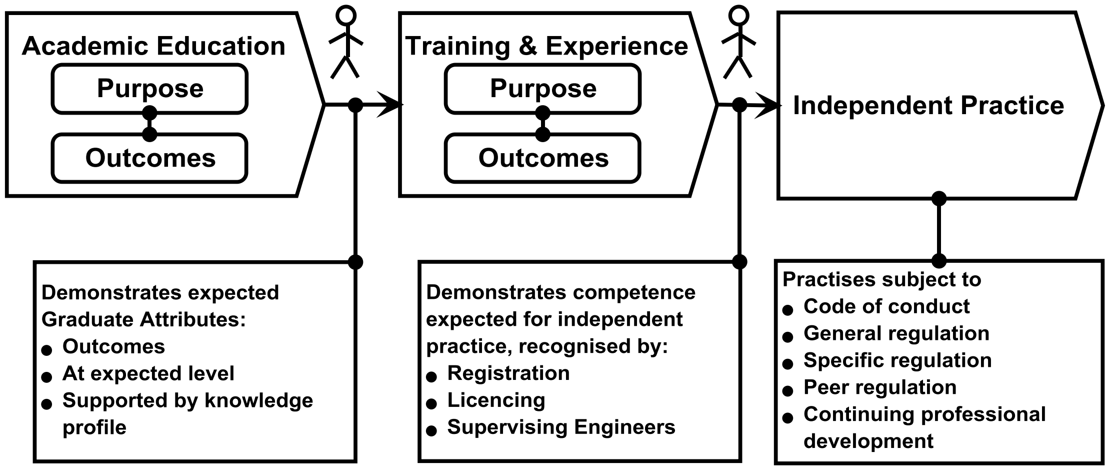

Figure 1: Reference model for the formation of an engineering professional

At the academic education level, accredited programmes have clearly defined purpose in relation to a particular engineering professional role and a set of assessable outcomes that give confidence that the programme achieves its purpose. Similarly a programme of training and experience after graduation has the purpose of developing the competence required for independent practice in the role. In several systems this competence is captured in a set of outcomes which must be demonstrated in an integrated manner through work performance. We root the following discussion on the principle that an educational programme or professional developmental activity must have a clear, professionally related purpose and a set of expected learning outcomes that are consistent with that purpose.

3. Comparison of IEA Accord Agreements and EUR-ACE System

The IEA and EUR-ACE recognition systems are considered here to illustrate the commonality and differences between systems. This table provides a reference for subsequent sections.

Table 1: Comparison of key characteristics of IEA Accords and EUR-ACE

IEA Education Accords	EUR-ACE System
Participants	
Signatories: accreditation agencies operating within specific jurisdictions A signatory may licence agent bodies to carry out defined accreditation functions.	Authorised accrediting agencies which may have national accreditation responsibilities but who evaluate programmes for the award of a EUR-ACE label for a stated cycle.
Authority and Decision Making	
Meeting of the signatories	ENAEE
Public Documents	
• Accord Agreements (IEA 2012) • Graduate Attributes and Professional Competencies (common to all Accords) (IEA 2013) • Rules and Procedures (common to all Accords), incorporating elements of best practice in accreditation (IEA 2012)	• EUR-ACE Framework Standards (EAFS) (ENAEE 2008a) comprising: − Section 2: Programme outcomes for accreditation − Section 3: Guidelines for programme assessment and accreditation − Section 4: Procedures for programme assessment and accreditation • Commentary on the EAFS (ENAEE 2008b)
Jurisdiction	
Signatories generally evaluate and accredit programmes within their own territories	No jurisdictional restrictions
Professional Purpose	
Each type of accord programme is intended to provide the educational component of professional formation toward a defined engineering role: engineer, engineering technologist or engineering technician	Accreditation is concerned with the educational part of professional formation, ensuring the suitability of a programme as the entry route to the engineering profession. Not explicitly linked to specific professional roles.
Standards	
Minimum standards are set by each signatory. Each Accord defines an exemplar of the expected standard. Signatory standards must be substantially equivalent to accord exemplar standard	EAFS Programme Outcomes for accreditation for the first and second cycle as well as integrated programmes
Processes	
Determined by signatories. Substantial equivalence to Accord best practice is evaluated by signatories on admission of new signatories and in periodic review of signatories	Determined by the EAFS: A peer review accreditation process, undertaken by appropriately trained and independent teams comprising peers from both academia and engineering practice.
Mutual recognition	
Signatories agree to recognize programmes accredited in other jurisdictions or, in the case of separate registering bodies, to make best effort to ensure that those bodies recognise programmes. With few strictly defined exceptions, mutual recognition applies only to programmes offered within territorial boundaries	EUR-ACE-labelled programmes are included in the Feani Index, affording recognition by bodies that follow the index.
Public Information on Accredited Programmes	
List/databases of accredited programmes maintained by each signatory	Labelled programmes are listed in the EUR-ACE database.

4. Principles and Approaches to Inter-system Benchmarking

Principles enumerated below are proposed as a means of controlling the complexity of inter-system benchmarking and development of mutual recognition arrangements.

4.1. Professional and Programme Purpose

When benchmarking documented and achieved standards between systems, the *professional purpose* of the qualifications must be clearly identified and be comparable. For example, the Washington Accord relates to qualifications that provide the educational base for practice as a professional, chartered or similarly titled engineer or, in jurisdictions where practice is unregulated, a person who is competent for independent practice at an equivalent level.

Professional formation and recognition systems vary across countries and regions. In particular, the division of responsibility for the practical component between the academic and practical training phases differs between systems. A reality in the present discussion is that, while engineering education models and accreditation systems have a good degree of consistency, professional competence recognition systems vary significantly, from compulsory licensure to no regulation of engineering practice. Definition of professional purpose has certain difficulties arising from the diversity of national systems and titles used (OECD 2011). Rather than assuming that titles give an understanding of professional purpose, it may be necessary to resort to professional profiles. In the IEA system, for example, the "engineer" and "engineering technologist" profile are captured in the Professional Competencies. Where these notions do not exist, the target professional profile should be used.

4.2. Achieved Standards as Basis for Recognition

Within each system, recognition of graduates is based on achieved standards, verified by the relevant accrediting agency using defined programme outcome standards. Within the IEA Accords, mutual recognition results from the members of the system verifying that individual the accrediting agencies apply defined standards and best-practice accreditation processes to ensure that desired standards are achieved. This principle applies equally to inter-system recognition. Progression toward inter-system recognition therefore involves both benchmarking of standards and developing confidence that the respective accreditation systems achieve specified outcome standards.

4.3 Common Approach to Programme Outcomes

Since 2000, the preferred paradigm for defining engineering programme criteria has shifted to using programme outcomes, that is the assessable graduate attributes that confirm that the purpose of the programme is being achieved. The IEA Accords and EUR-ACE conform to this model easing, the task of comparison.

This approach avoids difficulty in comparisons and mutual recognition when definitions of competency are limited by local identities of the engineer (Lucena et al 2008), for example as may be reflected in dominant types of engineering work in the country. Defining competence in terms of generic attributes that the engineer must be capable of to perform his or her set of tasks is preferred to defining the tasks, in any event an impossible task (Hager and Gonczi 1996). Adoption of graduate attributes as the primary specification for programme accreditation requirements frees education providers to design and implement programmes in different ways to meet the common requirements and to innovate. The accreditation system thus recognises the need for and facilitates diversity and innovation in programme design.

4.4 Principle of Substantial Equivalence

Evaluation of programmes against minimum standards is the norm in actual accreditation systems. When benchmarking or contemplating mutual recognition between accreditation systems, for example in the admission of an accrediting body as a Washington Accord signatory, the question is whether multiple systems, each accrediting against their own minimum standards, produce graduates who can perform on equal footing after graduation. The question is not whether all signatories apply a common minimum standard. This approach dates from when the Washington Accord's six founding signatories agreed to recognised the substantial equivalence of graduates of accredited programmes in the various jurisdictions and hence agreed to recognise each other's graduates. As additional signatories were admitted, formal evaluation of the substantial equivalence of the prospective signatory's standards and processes became the norm. A common understanding of the of the standard to be used in judging substantial equivalence was captured in the Graduate Attributes exemplar (IEA 2013) and indicators of a best practice accreditation system are contained in the Accord Rules and Procedures (IEA 2012).

The EUR-ACE system by contrast follows a minimum standards approach; the EAFS defines a common set of outcomes and Criteria and Requirements for Programme Assessment and Procedures to be followed.by authorised accreditation agencies in evaluating programmes for the award of labels.

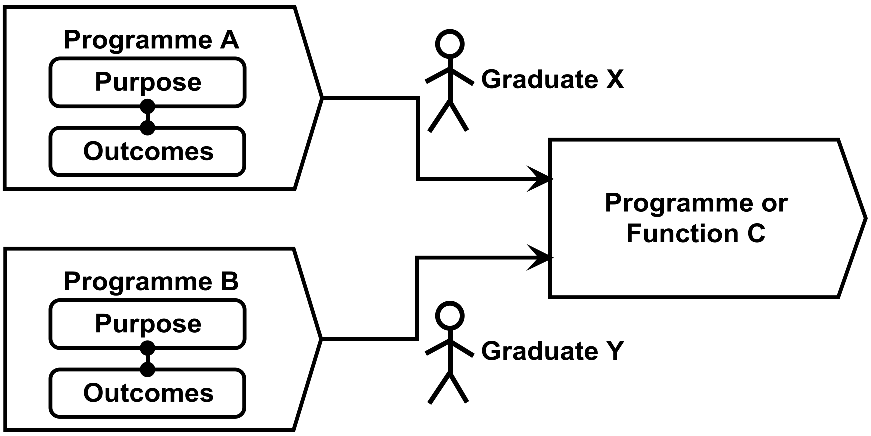

Figure 3: Illustrating the definition of substantial equivalence of programmes

Substantial equivalence applied to outcome standards is defined in the IEA Accord Rules and Procedures as: *achieving outcomes that whilst not individually identical to those of the standard or exemplar of that standard, taken cumulatively achieve the same overall outcome.* Two programmes, for example A and B shown in Figure 3, are substantially equivalent for a common professional purpose if their respective graduates are prepared to progress to the professional role via a common typifying programme C.

This definition contains several important principles. Implicitly, the focus is on achieved outcomes, not simply defined outcomes; it is therefore concerned with both the standards and accreditation processes. Judgement of substantial equivalence must be holistic: what is the end effect of the accredited education process, given that detailed differences may exist? Reference to the exemplar of a standard reflects the decision of the Accord signatories not to have a prescriptive minimum standard. The Graduate Attributes were formulated as an exemplar in the sense that a programme conforming to its specification would be one possible substantially equivalent programme.

5. Common Features of Existing Standards

The professional purpose of an educational programme determines the programme outcomes or graduate attributes. These represent a division of responsibility for professional formation between the education and practical training phases. The outcomes that provide evidence at the professional level are captured in the IEA Professional Competencies (IEA 2103) for the various professional roles and can be summarized as follows. Engineering practice rests on both engineering and contextual knowledge. The basic actions performed by the practitioner are to identify and analyse problems, to synthesise solutions and to evaluate all aspects of the analysis and solution, often using judgement. The practitioner must also ensure that the desired results are attained by performing engineering management. This core knowledge-based activity requires a number of supporting capabilities. Communication with professional and wider audiences is essential. In the process of the analyse-design-evaluate-act cycle, attention must be focused on regulatory matters, risks, impacts, especially negative ones, ethical issues. The practitioners act responsibly and take responsibility for the process and product. At an individual level, an engineering professional must continue learning to maintain and extend competence. These elements are common to engineers, engineering technologists and engineering technicians; the manner of using knowledge, the level of problem solving and the demand of the activities differentiate the roles.

National education standards as well as wider standards such as the IEA graduate attributes and the EAFS define a set of individually assessable outcomes consistent with the particular types of programmes. The IEA Graduate Attributes differentiate the Washington, Sydney and Dublin Accord programmes by means of *knowledge profiles* and a definition of the *range of problem solving*. The EAFS differentiate First and Second Cycle standards by means of statements regarding knowledge and problem characteristics but does not map these explicitly on to the diverse professional roles across Europe (OECD 2011).

Table 2: Essential elements of graduate competence as reflected in three standards

Attribute	IEA GA	EAFS	CDIO Syllabus
Apply knowledge: mathematics, natural science, engineering fundamentals and engineering specialization.	GA1	EA 1	1.1-1.3
Engineering Problem Analysis	GA2	EA 2	2.1
Engineering Design	GA 3	EA 3	4.3-4.6
Investigation	GA 4	EA 4.	2.2
Tools to support engineering activity	GA 5	EA 5	1.3
Societal, health, safety, cultural, legal issues	GA 6		4.1
Environmental and sustainability issues	GA 7		4.1
Ethics and responsibilities of engineering practice	GA 8		2.5
Individual and team effectiveness	GA 9	EA 6	3.1
Communication	GA 10		3.2
Engineering management	GA 11		4.2
Independent learning	GA 12		2.5.4

Outcomes are generally understood as stating *what graduates know and can do*. The knowledge of an engineering graduate has a profile for each role. Definition of what graduates can do involves both the action and the level of performance, and is linked to the enabling knowledge. The first level of comparison is the action part of the outcomes. Table 2 lists the action attributes covered by both the IEA graduate attributes and the EAFS programme outcomes. By way of confirmation from a programme implementation perspective, the alignment of the elements in the CDIO Syllabus (Crawley et al, 2011) with the action attributes is shown in the last column. Alignment is complete, save for enhancements in the CDIO Syllabus.

Table 2 confirms considerable consensus on the generic actions that are the foundation of an engineering educational outcomes standard. The next level of comparison involves the knowledge profile. Again there is substantial commonality: mathematics, natural sciences, engineering fundamentals, engineering specialist knowledge and contextual knowledge. The third level, namely the level of demand for each action, involves examining the range of problem solving as well as the various range and level indications built in to the outcome statements. The IEA graduate attributes have self-standing definitions of problem solving shown in Table 3 which are referred to in several outcome statements. Similarly, the IEA Knowledge Profile elements are referred to wherever necessary in each outcome.

Table 3: Extract from IEA Graduate Attributes Range of Problem Solving[1]

Washington Accord: *Complex Engineering Problems* have characteristic WP1 and some or all of WP2 to WP7*:*	**Sydney Accord: *Broadly-defined Engineering Problems*** have characteristic SP1 and some or all of SP2 to SP7*:*
WP1: Cannot be resolved without in-depth engineering knowledge at the level [defined in the WA Knowledge Profile] which allows a fundamentals-based, first principles analytical approach*	**SP1:** Cannot be resolved without engineering knowledge at the level [defined in the SA Knowledge Profile]with a strong emphasis on the application of developed technology§
WP2: Involve wide-ranging or conflicting technical, engineering and other issues*	**SP2:** Involve a variety of factors which may impose conflicting constraints
WP3: Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models*	**SP3:** Can be solved by application of well-proven analysis techniques§
WP4: Involve infrequently encountered issues*	**SP4:** Belong to families of familiar problems which are solved in well-accepted ways§
WP5: Are outside problems encompassed by standards and codes of practice for professional engineering	**SP5:** May be partially outside those encompassed by standards or codes of practice
WP6: Involve diverse groups of stakeholders with widely varying needs	**SP6:** Involve several groups of stakeholders with differing and occasionally conflicting needs
WP 7: Are high level problems including many component parts or sub-problems	**SP7:** Are parts of, or systems within complex engineering problems
*****Indicates close correspondence with EAFS Second Cycle statement § Indicates close correspondence with EAFS First Cycle statement	

Table 3 identifies the range statement elements that have close counterparts in the EAFS. In the case of the Washington Accord, elements WP1 to WP4 (shown thus *) are

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indicative of substantial equivalence of the level. WP5 to WP7 are not covered explicitly in the EAFS. However, a problem with characteristics WP5, WP6 or WP6 is likely to test affirmatively against WP3 or WP4. In the case of First Cycle Degree programmes EAFS level indicating phrases show correspondence with Sydney Accord elements SP1, SP3 and SP4 (shown thus [§]).

6. Conclusion

This paper is an exploration of issues that will arise in developing inter-agreement recognition and possible approaches as standards, quality assurance and recognition of accredited qualifications increases globally. The outcomes focused approach to programme standards provides opportunities for mutual recognition while allowing diversity in programme design and execution. Diversity of national systems and recognition mechanisms will need an appropriate approach. The IEA practice of basing mutual recognition of accredited qualifications on substantial equivalence rather than on compliance with a minimum standard is a tried and proven approach. Substantial equivalence must be judged by observation of the way that recognition systems operate, and their evaluation of their members' systems or programmes.

While the conclusions of section 5 are tentative, they indicate that there is a basis for further work toward establishing substantial equivalence between identified IEA Accords and EUR-ACE-lablelled programmes.

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