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Educational Requirements for Professional Practice: What's happening around the World?

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Abstract

Today, all over the world, engineers and engineering companies are working across international borders. Engineers in responsible charge are seeking avenues to legally practice across the globe. Most countries require either a credential or license in order to practice engineering and the educational requirements for such licensure (we will use licensure to refer either to a license or credential required to practice engineering in responsible charge) vary in many cases. Trends in overseas educational requirements in several countries and how those requirements might be evolving in response to both a greater body of knowledge for engineering and providing the attributes needed to effectively practice engineering on a global scale are explored herein.

ABET has begun accrediting foreign engineering programs. Today over 22 countries apart from the United States and its territories are participating. Another recent development is that the National Council of Examiners for Engineering and Surveying (NCEES) is beginning to offer their examinations overseas. At the same time mutual recognition agreements or efforts at harmonization moved forward in several countries. The Washington Accord, signed in 1989, promotes mutual recognition of engineering programs and now includes15 signatory countries and 5 provisional member countries.

The Bologna Accord, signed in 1999 had the following goals for 2010:

- it is easy to move from one country to the other (within the European Higher Education Area) – for the purpose of further study or employment;
- the attractiveness of European higher education is increased so many people from non-European countries also come to study and/or work in Europe;
- the European Higher Education Area provides Europe with a broad, high quality and advanced knowledge base, and ensures the further development of Europe as a stable, peaceful and tolerant community.

Now 47 countries are party to the accord.

The 1998 call for action from the 1995 Civil Engineering Education Conference of the American Society of Civil. Engineers[1], ultimately resulted in the passage of ASCE Policy Statement 465[2]—Academic Prerequisites for Licensure and Professional Practice. ASCE Policy 465 states that, in the future, education beyond the baccalaureate degree will be necessary for entry into the professional practice of civil engineering. Already several countries have recognized the need for advanced education for licensure or chartering.

This is one of several scholarly papers that will be written and presented about the preparation of engineers for licensure or equivalent outside of the United States. These papers will be written from different, yet related, perspectives including the (1) overview, (2) educational requirements for licensure in Asia and the United Kingdom, (3) ABET role and understanding

about overseas educational preparation for engineers , and (4) characteristics of global engineers. This paper will focus on the first perspective – overview.

Background

The American Society of Civil Engineers (ASCE) is a leader in reforming civil engineering to meet the needs of the future licensed professionals and better protect the health, safety, and welfare of the public. Work in this area ultimately resulted in the passage of ASCE Policy Statement 465—Academic Prerequisites for Licensure and Professional Practice. Policy 465 states that, in the future, education beyond the baccalaureate degree will be necessary for entry into the professional practice of civil engineering. Implementation of Policy 465 is manifested under ASCE'S "Raise the Bar" initiative. The most significant development to date is the incorporation of these principles in the National Council of Examiners for Engineering and Surveying's Model Law 2020[3], containing language approved by a majority of the NCEES member licensing boards and represent a best-practices model for licensure in the United States.

The vision for the future of civil engineer profession on a global scale is enunciated in the publication *The Vision for Civil Engineering in 2025* which imagines an end state where "Led by civil engineers, the global engineering profession has implemented broad changes to the academic prerequisites to professional practice. Today, those seeking admission to the professional practice of engineering must demonstrate that they have fulfilled the appropriate body of knowledge through education and experience. Gaining acceptance of the body of knowledge concept has taken more than 20 years, but is now common practice throughout much of the world."

Trends underway in Europe and elsewhere suggest that in many places this transformation of civil engineering may be taking less than 20-years. The U.S. risks falling behind in the global completion for mega projects and giga projects should we not address the changing needs of the engineering education for tomorrow's professional engineer in the near future. Ocampo surveyed the status of engineering in Europe and elsewhere in 2005[4] and concluding that the engineering profession is moving towards enhanced mobility and a common understanding of engineering titles.

Even domestically in the United States, educators are recognizing the limitations of a four-year baccalaureate degree in preparing tomorrow's professional engineers. As quoted in *The Engineer of 2020: Visions of Engineering in the New Century* "It is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four-year baccalaureate degree[5]."

Purpose and Scope

The objective of this paper is to briefly review several developments in the evolution of engineering education and subsequent licensure as a professional engineer (or practice of engineering in responsible charge) which generally requires some form of credentialing for selected countries. We also touch on programs at the NCEES and ABET for the international sector.

This is one of four scholarly papers that are scheduled for presentation at the 2013 American Society for Engineering Education (ASEE) Annual Conference in Atlanta under a session organized by the Civil Engineering Division. As a group, the four papers provide engineering educators and practitioners with a snapshot of many recent developments in licensure, supporting education, accreditation and attributes for global practice both in the US and around the world.

International Agreements and Accreditations

Many countries around the world have looked at harmonizing standards for engineering licensure and the supporting education. In the United States, ABET has begun accrediting foreign engineering programs. Today over 22 countries apart from the United States and its territories are participating. Another recent development is that the National Council of Examiners for Engineering and Surveying (NCEES) is beginning to offer their examinations overseas. At the same time mutual recognition agreements or efforts at harmonization moved forward in several countries. The Washington Accord, signed in 1989, promotes mutual recognition of engineering programs and now includes15 signatory countries and 5 provisional member countries. Details about foreign countries participating in ABET's overseas program and the Washington Accord can be found in the companion paper in this session entitled *ABET's Global Engagement*[6].

The European countries have adopted the Bologna Accord or Model. The agreement, signed in 1999, had the following goals for 2010[7]:

1. it is easy to move from one country to the other (within the European Higher Education Area) - for the purpose of further study or employment;
2. the attractiveness of European higher education is increased so many people from non-European countries also come to study and/or work in Europe;
3. the European Higher Education Area provides Europe with a broad, high quality and advanced knowledge base, and ensures the further development of Europe as a stable, peaceful and tolerant community.

Now 47 countries are party to the accord and a complete list is included in appendix 1. Many other countries are looking at the model for possible future implementation. The model conceives a three tiered approach to engineering education. Generally one first completes a three-year undergraduate degree. During the second phase additional education is garnered either through a master's degree or additional professional training lasting about two years or longer. Finally a professional doctorate or PhD might be pursued to achieve the third tier.

The European Commission is the elected body representing the interests of the European Union as a whole. The Commission proposes new legislation to the European Parliament and the Council of the European Union, and it ensures that EU law is correctly applied by member countries[8]. Directive 2005/36/EC on the Recognition of Professional Qualifications came into force in 2007[9]. It includes the profession of engineering. FEANI (European Federation of National Engineering Associations) leads efforts in mutual recognition of professional qualification with respect to education and training for engineers[10].

FEANI developed the Engineering Card, as a mutual recognition credential for Europe in 2011. This capped several decades of work including development of a European Register of Higher Technical Professions in 1970 and revised FEANI Register in 1992 to “facilitate movement of practicing engineers inside and outside the FEANI area and to establish a framework of mutual recognition of qualifications in order to enable engineers who wish to practice outside their country to carry with them a guarantee of competence” and to “provide information about the various formation systems of individual engineers for the benefit of prospective employers.” The Engineering Card is wallet sized credential that provides photo and other identification on one side and a comparative educational profile on the back.
Another important party in European accreditation is the European Network for Accreditation of Engineering Education (ENAEE). ENAEE operates the Accreditation of European Engineering Programs (EUR-ACE) Framework and is looking at expanding globally[11].

United Kingdom

The United Kingdom recognizes three kinds of engineering competence[12] including:

- Engineering Technician (EngTech);
- Incorporated Engineer (IEng); and
- Chartered Engineer (CENG).

This program is administered by the United Kingdom’s Engineering Council.

In the late 1990’s Great Britain increased the requirements for Chartered Engineer status to include “an accredited Bachelors degree with honours in engineering or technology plus either a master’s degree accredited by a professional engineering institution, or appropriate further learning to the master’s level”. Alternatively a candidate could complete an accredited integrated MEng degree. Previously Chartered Engineers were not required to complete advanced education. Engineers not completing advanced education, but completing an accredited Bachelors degree in engineering or technology may apply for Incorporated Engineering status. It’s interesting to note that while a British bachelor’s degree is typically three years, there is considerable preparation in the final year of high school that is similar to many freshman courses in mathematics and science.

The Chartered Engineers Standard states “Chartered Engineers are characterised by their ability to develop appropriate solutions to engineering problems, using new or existing technologies, promote advanced designs and design methods, introduce new and more efficient production techniques, marketing and construction concepts, or pioneer new engineering services and management methods. Chartered Engineers are variously engaged in technical and commercial leadership and possess effective interpersonal skills”[13] (Engineering Council, 2011).

In addition, the competence and commitment standard defines over 16 characteristics under five major categories including:

A. Using a combination of general and specialist engineering knowledge and understanding to optimize the application of existing and emerging technology;

B. Applying appropriate theoretical and practical methods to the analysis and solution of engineering problems;
C. Providing technical and commercial leadership;
D. Demonstrating effective interpersonal skills; and
E. Demonstrating a personal commitment to professional standards, recognizing obligations to society, the profession and the environment.

Candidates for chartered engineer status must document their experience with their employer(s) to demonstrate achievement of the above characteristics. It is not uncommon for it to take four to six years of practice achieve the standard. There is also a requirement for maintaining competency through continuing education and service to Engineering Council licensed professional engineering institutions. Engineers also subscribe to a code of conduct that stresses integrity and acting in the public's interest.

Ireland

In the 2009 Ireland increased the requirements for Chartered Engineer status to include advanced education effective in 2013. Several of the pathways to achieving advanced education include[14]:

- "You may choose to complete a masters degree in an engineering programme accredited by Engineers Ireland of minimum one year duration.
- You may choose to complete a masters degree in an engineering programme unaccredited by Engineers Ireland of minimum one year duration. This includes research master degrees and those completed outside of Ireland.
- You may choose to continue your educational formation by completing further learning equivilents to the learning outcomes expected of a graduate of a masters degree in engineering accredited by Engineers Ireland.
- Further learning will likely be accomplished through a combination of a number of learning and development activities. These activities may include the completion and application of:
- a masters degree in another subject area (eg: MBA, MSc. etc.)
- a module of further study at masters degree level (eg: a diploma at level 9 on the Irish National Framework of Qualifications such as the Engineers Ireland Future Professionals Programme
- a range of CPD certified training plus proven application of the learning outcomes
- a work based research project facilitating the development of the required learning outcomes."

Similar to the United Kingdom, Ireland includes two other levels for engineering professionals including Associate Engineer and Engineering Technician. Additionally, Chartered Engineers with more than five-years of experience and meeting certain other qualifications may apply for "Fellow" status.

Ireland made the switch to master's or equivalent to maintain the quality of professional engineering in Ireland and to align itself with European best practices. The change is not retroactive and current members of Engineers Ireland with Chartered Engineer titles are grandfathered[15].

Germany

German engineering education is also evolving along the lines of the Bologna Model. The status of Engineer is protected under German Law under the "Laws of Engineers (Ingenieurgesetze) which sets the requirements for engineering practitioners. The supporting education is moving from a single diploma into a two-tiered bachelor's and master's approach. Today, one must complete both degrees to use the title of "Diplom-Ingenieur". Additional certified experience and achievement of competency standards is required for civil engineers and these engineers must be members of the Engineers Chambers in their state[16]. (UNESCO, 2010). Such engineers are called Beratender Ingenieur[17] (Consulting Engineer in English) and are legally authorized to practice engineering. They must maintain their status in the state registration list. Verein Deutscher Ingenieure (VDI, Association of German Engineers in English) represents Germany to FEANI. German engineers can apply for membership in VDI and can use the credential after their name. Today German engineers would apply for the Engineering Card described earlier to practice engineering in other parts of Europe.

Australia

Although Australia has yet to adopt a master's or equivalent model for obtaining chartered engineer status, there is positive movement in that direction via the Melbourne Model for engineering education[18]

Australia divides engineering programs into three categories"

- Professional Engineer;
- Engineering Technologist; and
- Engineering Associate.

One may obtain chartered status in any one of these three areas. Chartered engineers in Australia must complete 150 hours of continuing professional development every three years with specific requirements as outlined on the engineersaustralia.org.au website.

The Melbourne Model includes three degree structured as follows:

- "A three-year undergraduate degree (the three year 'new generation degrees' are 'stand-alone'degrees, in the sense that on completion graduates may seek employment or pursue further study);
- If further study is chosen, the undergraduate degree may be followed by either further scholarship (e.g. masters by research) or professional training (e.g. a two year (or possibly longer) professionally accredited program);
- If further study is chosen by the student, the professional master's degree may in turn be followed by a three-year doctoral program (i.e. either a PhD by research or, in some Faculties, professional doctorates).

The structure is consistent with European Bologna model described earlier and offer several additional benefits including:

- "An enriched 'Melbourne Experience' through distinctive undergraduate courses which offer pathways into professional graduate programs, but which also stand alone as strong degrees;
- A strong discipline-based education, including an introduction to research;
- Closer alignment of course structures with desired graduate attribute outcomes
- An improved classroom experience, including smaller classes.
- Stronger likelihood of well-rounded and motivated graduate students.
- Degrees developing interdisciplinary skills and preparing graduates for a variety of postgraduate programs, as well as employment in diverse workplaces;
- The development of well-rounded and motivate students;
- Broader access for students especially those from disadvantaged backgrounds; and
- A strengthening of international recognition of degrees at the UofM."

New Zealand

Some universities in New Zealand offer a combined 3 years bachelors of science degree combined with a two year masters for a total of five years as an alternative to a four-year bachelors of engineering degree. University College Dublin is one such example[19]. Additionally several universities are adding an additional half semester of study to their traditional four year programs[20].

The Institution of Professional Engineers New Zealand (IPENZ) is the professional association which represents professional engineers across all disciplines in New Zealand[21]. Practitioners can practice under several categories in New Zealand including:

- Chartered Professional Engineer (CPEng)
- International Professional Engineer (IntPE(NZ))
- Engineering Technology Practitioner (ETPract)
- International Engineering Technologist IntET(NZ))
- Certified Engineering Technician (CertETn)

The requirements for "International" appear similar to those for domestic practitioners; however they have taken the extra step of listing themselves in the International Professional Engineers or International Engineering Technologists Register. IPENZ further defines twelve competence standards for professional engineers including[22]:

1. Comprehend, and apply knowledge of, accepted principles underpinning widely applied good practice for professional engineering;
2. Comprehend, and apply knowledge of, accepted principles underpinning good practice for professional engineering that is specific to the jurisdiction in which he/she practices (for CPEng assessment this relates to the jurisdiction of New Zealand);
3. Define, investigate and analyse complex engineering problems in accordance with good practice for professional engineering;

4. Design or develop solutions to complex engineering problems in accordance with good practice for professional engineering;
5. Be responsible for making decisions on part or all of one or more complex engineering activities;
6. Manage part or all of one or more complex engineering activities in accordance with good engineering management practice;
7. Identify, assess and manage engineering risk;
8. Conduct engineering activities to an ethical standard at least equivalent to the relevant code of ethical conduct;
9. Recognise the reasonably foreseeable social, cultural and environmental effects of professional engineering activities generally;
10. Communicate clearly with other engineers and others that he or she is likely to deal with in the course of his or her professional engineering activities;
11. Maintain the currency of his or her professional engineering knowledge and skills; and
12. Exercise sound professional engineering judgement.

Next Steps

ASCE staff is collaborating with the SIG (Special Interest Group) for International Engineering Education under the Corporate Member Council of the American Society for Engineering Education. This group is developing attributes of a global engineer. These attributes represent the desired competencies and characteristics needed by engineers in order to effectively live and work in a global context. ASCE also continues to advocate for the full implementation of NCEES Model Law 2020, raising the bar for a professional engineers foundational education to include an additional 30 upper division or graduate level graduates beyond the ABET accredited bachelor's degree in engineering. It may be useful in the future to expand this paper and offer more side by side comparisons, however not all the criteria for licensure are black and white and the licensing systems vary greatly, even within Europe so often times a tabular comparison is difficult.

Conclusion

The world is truly becoming a smaller place with respect to engineering. Design centers abroad, outsourcing of CADD, international accreditation of degree programs and accords fostering the mobility of professional engineers. Developments in global engineering education are important in terms of ensuring the maximum mobility both domestically and abroad. As Dr. Peter Greenwood concluded in his paper[23] "It is clear that improvements in engineering education and training are needed in the engineering. They should be implemented despite the continuing effects of the Global Financial Crisis and the continuing skills shortage." Thus at a time when credit hours are declining at many US universities with respect to engineering programs, we are seeing competitor nations up the ante on education.

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Appendix 1

Member Nations Party to the Bolgona Accord

Albania	Germany	Norway
Andorra	Greece	Poland
Armenia	Holy See	Portugal
Austria	Hungary	Romania
Azerbaijan	Iceland	Russian Federation
Belgium	Ireland	Serbia
Bosnia and Herzegovina	Italy	Slovak Republic
Bulgaria	Kazakhstan	Slovenia
Croatia	Latvia	Spain
Cyprus	Liechtenstein	Sweden
Czech Republic	Lithuania	Switzerland
Denmark	Luxembourg	The former Yugoslav Republic of Macedonia
Estonia	Malta	Turkey
Finland	Moldova	Ukraine
France	Montenegro	United Kingdom
Georgia	Netherlands	