Solving the Impasse Among the Engineering Disciplines: Finding Common Ground for the Educational Requirements for Tomorrow's Professional Engineers

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Abstract

Reports about the future of engineering education intended to promote the skills, knowledge, and attributes necessary for engineering practice and to better protect the public were widely discussed and published throughout the 20th century. During the past several years, there has been a great deal of discussion around the idea that a baccalaureate degree is not sufficient to produce the engineer with the required skill set to practice as a professional engineer in the 21st century. Initially it was considered that a master's degree in engineering could compensate for the shortfall of technical depth needed for effective practice. Upon further study it was determined that the master's degree was not necessarily the most effective path for all engineering disciplines and all engineers. Some disciplines have a very effective program for on-the-job learning in the early stages of a professional career. Others sought to enhance business acumen and education through a combination approach with both business and engineering coursework, beyond a bachelor's degree—perhaps an MBA. This led to the development of a concept of equivalent credits to a master's degree. Recently the American Society of Civil Engineers organized a task committee to study the "equivalent 30" concept. Meanwhile, the Education Committee of the National Council of Examiners for Engineering and Surveying (NCEES) was charged with developing "required standards for assessing non-university coursework, paying particular attention to the rigor required for equivalency" and to "[u]se input from entities that currently provide meaningful, non-university courses." The NCEES Education Committee also came to a key conclusion in 2014. Based on the Education Committee's collaborations and interactions with several key professional societies, the committee has made a substantive determination: The search for "equivalency" is not appropriate. Any education initiative using practice-oriented education is clearly different from university coursework and thus cannot be judged as being equivalent. It is likely that in the near future, the development of a new practice-oriented pathway will become a top priority for the Committee. This scholarly paper will delve into a series of questions about the future of engineering education outside of the traditional master's degree in engineering pathway, including

- What constitutes a practice-oriented pathway?
- What is the role of NCEES and ASCE in advancing such a pathway?
- How is the practice-oriented pathway distinct from the academic pathway?
- How might the various engineering societies collaborate to offer a practice-oriented pathway?

Introduction

During the past several years, there has been a great deal of discussion among professional engineers around the idea that a baccalaureate degree is not sufficient to produce the engineer with the required skill set to practice as a professional engineer in the 21st century. This has led to the development of initiatives at certain professional societies and at the National Council of Examiners for Engineering and Surveying (NCEES) to define and implement a plan for modifying the educational requirements for a licensed professional engineer. Their work was supported over 10 years ago by a National Academy of Engineering report that concluded, "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"[1]. An earlier NAE report concluded that "...if the engineering profession is to take the initiative in defining its own future, it must ... agree on an exciting vision for the future; transform engineering education to help achieve the vision"[2]….

Recently the American Society of Civil Engineers (ASCE) organized a task committee to study the "equivalent 30" concept. Meanwhile, the Education Committee of the National Council of Examiners for Engineering and Surveying (NCEES) has been actively working on a concept whereby a practice-oriented pathway could be an acceptable alternative to the "equivalent 30".

Initially it was considered that a master's degree in engineering could compensate for the shortfall of technical depth needed for effective practice[3]. Upon further study it was determined that the master's degree was not necessarily the most effective path for all engineering disciplines and all engineers. Some disciplines have a very effective program for on-the-job learning in the early stages of a professional career. Others sought to enhance business acumen and education through a combination approach with both business and engineering coursework, beyond a bachelor's degree—perhaps an MBA. This led to the development of a concept of equivalent credits to a master's degree.

In this paper, the coauthors explore work on equivalency first from the perspective of NCEES and then from the perspective of ASCE.

The Equivalency Concept Discussion at NCEES

The charge that was given to the NCEES Education Committee in late summer of 2013 relative to the "equivalent 30" concept was the following:

Develop required standards for assessing non-university coursework, paying particular attention to the rigor required for "equivalency." Use input from entities that currently provide meaningful, non-university coursework.

During the Education Committee meeting there was a great deal of discussion that centered on the equivalency concept of Masters or Equivalent (MOE). A strict interpretation of the term "equivalent" could mean that an educational offering should require the same number of hours "inside and outside the classroom" as is typical for a college course where credits are earned.

Additionally, equivalency under such a definition should require the same educational rigor and assessment (testing, homework, etc.) as the comparable type of college-credit course.

One committee member formulated a device that looked like an equation to explain his ideas on equivalency:

$\mathbf{E=R^3}$ where:

E=Equivalency
$\mathbf{R^3}$=Relevancy*Rigor*Requisites

Such an equation could be applied to any courses or programs proposed for sanction as being "equivalent" to a master's-degree-type course or program.

Much of the discussion centered about how the committee defined Relevancy, Rigor, and Requisites for courses and program offerings.

Relevancy might refer to how a proposed offering improves the technical, business, or ethical capabilities of engineers who successfully it.

Rigor refers to the fact that any offering must be equivalent to a university course, or the most demanding professional training on a topic (i.e., no "bunny" courses allowed).

Requisites refer to the criteria and logistics of course or program offerings, e.g.,

- The objectives and outcomes of the offerings
- The scope and duration of the offering
- The setting for the offering (classroom, hotel, online, etc.)
- The qualifications of instructors and organizations who deliver the content
- Criteria for attendee admission, including prerequisites
- Assessment of learning outcomes and achievement of objectives from the offering by attendees
- Certification of successful completion

It was noted during this presentation that the listing of these items were similar to EAC/ABET criteria.

If the MOE is adopted by state boards of licensure, it would become the standard of admission for qualified candidates who sit for the PE exam. So the question being raised and debated by the committee was, What is equivalent to 30 hours of postbaccalaureate academic work that would lead to an MS degree in engineering? Is it simply 375 contact hours?

This narrowly scoped definition is a nonstarter for certain technical engineering societies that deliver coursework in settings other than college classrooms, such as workshops and short courses. For these societies and their members, the term "or equivalent" should disappear from any laws or rules or guidelines, and the term "or alternative" should replace it.

The consensus from the discussions at the meeting was that rather than focusing exclusively on measuring the equivalence in educational content and form between coursework provided in formal, institutional teaching environments and coursework gained outside of that environment, it may prove more productive to expand the focus to include alternative (i.e., additional) pathways to achieving and assessing practical mastery of the body of knowledge (BOK) necessary to practice professional engineering. Such a regime would envision the concept of additional education prior to licensure based on **either (**1) a master's degree or equivalent earned through formal educational programs, or (2) an independent pathway demonstrating practical mastery achieved through other than purely educational means.

In 2013, the NCEES Education Committee met with representatives from five technical engineering societies to (1) understand how the societies currently deliver nonuniversity coursework to their members, and (2) determine whether a practice-oriented pathway could be developed that would be "equivalent" in rigor and assessment to courses that are part of the "plus 30" concept.

At the conclusion of the work of the NCEES Education Committee in 2014, a report was written. One of the key findings resulted from the technical society presentations and the subsequent discussion and deliberation by the committee members. A substantive determination made by the committee was that "the search for equivalency is not important." Furthermore, any education initiative utilizing a practice-oriented approach is clearly "different" than university coursework and thus cannot be judged as being equivalent.

Therefore, there is strong sentiment that fulfillment of a future requirement for either a master's degree or equivalent must include an additional pathway that is practice-oriented by its nature. This pathway would seemingly place a high demand on approval by the technical engineering societies in the establishment of depth and breadth criteria for education in the respective disciplines.

Several societies have published a body of knowledge for their disciplines. The Education Committee encourages all technical societies to do so. Those that already have are adamant about the critical need for additional technical education in their discipline, but they also all agreed that this education should not necessarily be provided solely through academic coursework. Rather, it should include at least some practice-oriented offerings very much like those currently provided by several societies. The committee believes that such a shift in focus may establish a new approach that will enable professional engineers of the future to better serve and protect the health, safety, and welfare of the public.

What Constitutes a Practice-Oriented Pathway?

Although there are a variety of ways that practice-oriented pathways can be configured, one concept that has gained traction by a technical society whose members typically do not pursue degrees beyond the baccalaureate degree is special training by that society. The additional education they seek for professional practice is usually not received in college engineering

courses, but rather is learned as part of their employment. The practice-oriented pathway that would work for this society would consist of workshops or short courses that could be several days in length, taught by qualified professional engineers having experience and expertise in the subject area. The subject matter of these workshops or short courses is designed to be germane to their career development and within the body of knowledge of their engineering discipline. Their learning would be assessed at the conclusion of the workshop through written testing and/or a practicum. The details relative to the number and types of offerings that would be needed to fulfill the additional education requirement prior to licensure would need to be developed. In any case, it seems clear that this type of alternative is different than strictly coursework offered at universities and would not be judged as equivalent. Nevertheless, it is a concept that seems to hold a lot of promise.

How Might the Various Engineering Societies Collaborate to Offer a Practice-Oriented Pathway?

Most technical engineering societies offer coursework to their members to fulfill continuing education requirements for licensure. The coursework takes on many different formats relative to content, delivery method, and course length. Nevertheless, all societies embrace the idea that lifelong learning is important and that continuing education courses are an ideal way to fulfill that growth. This same thinking can be used to design coursework for the practice-oriented pathway which would necessarily be more robust than it would be for continuing education courses.

Despite the fact that some technical societies embrace the MOE concept to a greater extent than the practice-oriented pathway, members of all societies (and even individuals who are not members of any society) can benefit from such an alternative. Therefore, it is important that all societies collaborate to offer this pathway. They can do so by working to develop common standards for course content, delivery, and assessment.

These standards could take the form of "approved course requirements" that would be necessary for the courses to "count" toward the fulfillment of the additional education. For example, all the societies could collaborate to classify all educational courses into one of the following categories:

- Core Technical Courses—Any content that is directly applicable to the design, operations, application, or maintenance of engineered systems, products, buildings, or structures. This area includes all technical topics related to the protection of the health, safety, and welfare of the public.
- Professional Practice Courses—Any content relative to the professional practice of engineering; examples would be business, communications, contract law, management, ethics, public policy, and quality control.

Due to the nature of technical societies and/or industries and consulting firms who might offer these courses, most of them could be one-day to one-week-long workshops and could include course content that is proprietary in nature.

In addition, the societies could collaborate to develop course requirements that must meet the following standards to qualify for credit:

- Have a clear purpose with stated and relevant learning objectives tied to professional practice
- Be current, technically accurate, and effectively designed (i.e., rigorous)
- Be developed by individuals qualified in the subject matter and instructional design
- Be delivered by individuals qualified in the subject matter and instructional methods, preferably licensed engineers
- Be reviewed periodically and updated as necessary; no educational offering should be offered longer than two years from initial offering without revision or thorough review

Finally, each educational activity should be evaluated with an appropriate mechanism to measure whether learning objectives were met. Additionally, the approved course provider should provide an individual student assessment of the course for technical content, assessment of the instructor, and assessment of the course delivery.

All asynchronous distance learning educational activities should also have a periodic as well as an end-of-activity examination. The assessments must be in the form of an objectively based examination with at least five questions from every contact hour of instruction. A minimum passing score of, for example, 70%, would be required to receive credit for the activity.

Not only engineering societies but employers are envisioned to have a role in facilitating a practice-oriented pathway for licensure. Many engineering firms have in-house training and development groups where courses are offered for continuing education credit. These courses generally fit into professional practice (as opposed to technical) subject areas. Many of these courses could fulfill the body of knowledge in certain engineering disciplines' professional practice areas. In addition, many industries employ engineers who are trained in courses proprietary to the processes and methods used by the industries but which are not taught in college engineering programs. These types of courses could also fit within the practice-oriented pathway. In all these examples, employers could be approved course providers for those engineers who seek to become licensed using the practice-oriented pathway.

The ASCE Raise the Bar Committee and Its Predecessor Committees' Work on Equivalency to the Master's Degree

The idea that the educational pathway to professional engineering licensure needs to change is not a new concept. The modern history of the Raise the Bar initiative was presented at the 2012 ASEE Conference[4] documenting a chronology dating back to a 1995 ASCE Civil Engineering Education Conference (CEEC '95) in Denver. Although the initiative initially focused on a master's degree in engineering as the first professional degree, consultation with stakeholders and work by the NCEES's Engineering Licensure Qualifications Task Force (ELQTF) led to a decision to allow either a master's degree in engineering or an equivalent 30 credits beyond a bachelor's degree which met certain criteria contained in the 2013 NCEES Model Law[5] and Model Rules[6] (see Appendix A).

In 2004, ASCE published the *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future*[7]. Four years later, a second edition with the same title was published[8] and contained 24 desirable outcomes, which provided more detailed clarification than the 15 originally proposed. The document identified specific levels of achievement from Bloom's taxonomy and when and where those levels were achieved, including

- bachelor's degree in engineering,
- master's or equivalent, and
- work experience as an engineer intern.

An early step in defining the equivalent 30 credits was undertaken by the ASCE Body of Knowledge Fulfillment and Validation Committee. It issued a report in 2005 titled *Fulfillment and Validation of the Attainment of the Civil Engineering Body of Knowledge*[9]. The committee concluded that the B+30 path is a viable option for acquiring the BOK. It also recommended that existing entities such as ABET provide the course approval process and that NCEES review the acceptable courses.

Work in further defining the equivalent or plus 30 credits concept continued in 2008. The ASCE Plus 30 Task Committee (P30TC) was created in October 2008 and charged[10] to "explore what the +30 credits should be, and with identifying practical alternatives for how civil engineers can attain +30 credits that will be required for licensure as a professional engineer in the future – and that are beyond the requirements of an accredited baccalaureate engineering degree. The charge directed that specific attention be focused on alternatives such as corporate universities, public agency professional development programs, professional intensive short courses, and non-engineering degree programs. Simply speaking, the charge is:

1. Define +30 credits in terms of technical and professional practice focus areas.
2. Identify acceptable courses for +30 credits and recommend guidelines and mechanisms to identify future courses.
3. Recommend guidelines and mechanisms to identify means to acquire the +30 from nonacademic providers.
4. Recommend guidelines and mechanisms to identify approved course providers for these acceptable courses.
5. Prepare a report documenting its findings and recommendations."

The P30TC concluded the following:

1. "P30TC notes that the civil engineering profession, more than others, is heavily involved in the complex interactions between the built and natural environment and the public.
2. P30TC supports the concept of a Civil Engineering Body of Knowledge (BOK) defining the necessary depth and breadth of knowledge, skills, and attitudes required of an individual entering the practice of civil engineering at the professional level.
3. P30TC finds that the recently defined BOK responds to the technical challenges and non-engineering requirements of the 21st Century.
4. P30TC agrees that attainment of the BOK requires completion of an appropriate Master's degree or a minimum of 30 credit hours of higher level course work beyond the baccalaureate.

5. P30TC believes that the 30 credit hour approach is an important and feasible alternative to a Master's degree.
6. P30TC believes that an individual can obtain 30 credit hours through a degree in a related field (e.g., MBA, MPA, etc.) provided it includes at least 15 engineering technical credits and up to 15 additional credits in courses relevant to the practice of engineering.
7. The P30TC agrees that in the future it is viable for ASCE to serve as the validating agency for non-traditional educational components."

Although the P30TC developed many fine conclusions in its 2009 report to the ASCE Board of Direction, charge 2, "Identify acceptable courses for +30 credits," still remained to be accomplished.

The Equivalent 30 Credits Task Committee of RTB

In 2012, the Raise the Bar Committee (RTBC) began seeing efforts by NCEES to develop a kind of registry or clearinghouse approach toward managing the acceptance of 30 additional credits in lieu of master's degree in engineering by the 55 professional engineering boards in the United States. At the same time, more and more engineers were asking questions about the equivalent 30 credits and discussions began to occur in social media spaces such as LinkedIn. One void recognized by RTBC was the lack of definition of acceptable pathways to achieve the equivalent 30 credits. The RTBC sought to create a task committee composed of members with expertise in academic, association, corporate, and agency educational programs to produce a report containing several hypothetical pathways that engineers could follow to complete the equivalent 30 credits.

What Pathways Were Identified by the Committee?

In September 2014, the Equivalent 30 Credits Task Committee of RTB completed its charge by finalizing a report entitled *Example Pathways to 30 Credits: Alternatives to a Master's Degree under "Master's or Equivalent"*[11]. The pathways were not intended to represent all possible combinations and permutations, but rather five easy-to-understand examples using fictional engineers, as shown below. Classes could be offered by a variety of providers, among them universities, employers, professional societies, and trade associations.

"Scenario 1: College Credits Only, No Master's Degree—After graduation with a bachelor's degree in engineering, Emily Post Bakaloriat already had six credits that qualified for the equivalent 30 credits path (college courses not needed to fulfill her BSE degree requirements). After going to work, she obtained the additional 24 credits by taking one three-credit course each semester either at her nearby alma mater or evening courses online from universities across the country.

Scenario 2: Firm's In-house Courses as First Choice—Jack Inhouser works for a large engineering firm that maintains an in-house "university." Such in-house education programs are generally not in a position to offer many technical courses, focusing primarily on topics related to leadership and management. Jack took 18 two-day in-house courses which, with pre-work and homework, counted as one college credit each. Fifteen of the credits were non-technical; three

technical. He obtained the remaining 12 of his needed 15 technical credits through outside online courses.

Scenario 3: Technical Associations as Only Source—Nonie Proffit, a graduate mechanical engineer, works for an employer who provides educational reimbursement only for courses directly applicable to her job. To meet this company requirement, Nonie took courses from technical/professional associations, including certification courses that provided credentials in building energy use, building energy modeling, and plumbing design. The larger technical societies had added homework and assessment to numerous courses and thus had become approved for equivalent 30 education.

Scenario 4: Credits from Multiple, Diverse Providers—Manny Sources received a BS in civil engineering after attending two different community colleges and a large university. Working for a small roadway design company, he focused on variety for equivalent 30 education. He enrolled in management and leadership training, in-person college and online college classes, professional association and private provider courses, and an association certification program.

Scenario 5: Industry Employer as Key Source—Eli Trik, a graduate electrical engineer, works for a large regional electric company. For the advanced education to pursue licensure, Eli concentrated on the specific engineering aspects of his new employer, which were covered in the company's in-house electric power-related education. Overall, he generally matched Jack Inhouser's approach (Scenario 2), except Eli included an online graduate certificate program."

The requisite equivalent 30 credits were achieved in each scenario and met the varied needs and backgrounds of the individuals involved.

Conclusion

A considerable amount of work remains before a practice-oriented approach could be considered an alternate pathway within the MOE language. It appears, however, to be a viable pathway and when fully developed would be different than one that involves traditional academic coursework. With the cooperation of all technical societies, the NCEES Education Committee stands ready to continue its development of a practice-oriented pathway as an alternative to the "equivalent 30 credits" of the MOE concept. References such as the ASCE Equivalent 30 Committee Report may assist this effort.

The *Example Pathways to 30 Credits: Alternatives to a Master's Degree under "Master's or Equivalent"* report concluded that "the diversity of possible approaches to achieve the equivalent 30 credits provides flexibility for employees and employers in fulfilling the future educational needs for licensure under the MOE provisions. Licensure candidates can find an approach that fits them and their employers by mixing and matching in-person and online courses while taking advantage of public and private universities, company and agency in-house programs, private sector vendors, and associations." The key will be a registry and guidelines on what constitutes an approved course under the equivalent approach when courses are taken outside a university setting.

Some critics of Raise the Bar have cited the increased financial obligations for students associated with graduate studies as a reason to oppose the initiative. ASCE believes that advancing education requirements for licensure will ultimately enhance the health, safety, and welfare of the public by ensuring that future professional engineers have mastered the ever-expanding body of knowledge. Equivalent 30 credits may offer individuals other, more cost-effective means of achieving the future post-baccalaureate requirements for licensure. It certainly would provide a means of achieving an engineering income stream earlier than a master's degree earned immediately after completion of a bachelor's degree. It would not be uncommon for employers, in developing the technical and professional capabilities of their more competent engineering interns, to invest in short courses, in-house training, and even further academic courses, to make them more effective professional engineers and team leaders. Others will still opt to complete an engineering master's degree to gain a deeper understanding of their field and perhaps enhance their earning potential.

The vision for the future of the civil engineer profession on a global scale is enunciated in the publication *The Vision for Civil Engineering in 2025*, which imagines a future where *"*[l]ed 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"[12].

Note that the views and opinions expressed in this paper are the authors' and do not necessarily reflect ASCE or NCEES policy or the policies of the other entities envisioning the future of engineering education.

Change is constant, but, on an absolute basis, our world has changed more in the last one hundred years than in all those preceding"[13].

—Educating the Engineer of 2020, National Academy of Engineering

Appendix A
MOE Provisions of the NCEES 2013 *Model Law*[14] *and Model Rules*[15]

The MOE provisions outline the following requirements for the equivalent 30 credits pathway:

- At least 15 of the minimum 30 credits must be technical upper-level undergraduate and/or graduate-level courses in engineering. The remaining 15 can be of the same technical nature, if so wished, or they can be other courses relevant to the practice of engineering, including engineering-related science, mathematics, and professional practice topics, the latter including topics such as business, communications, contract law, management, ethics, public policy, and quality control.
- All 30 additional credits must be equivalent in intellectual rigor and learning assessment to upper-level undergraduate and/or graduate courses offered at institutions that have a program accredited by EAC/ABET.

- None of the 30 credits can have been used to fulfil the bachelor's degree requirement.
- The term "credit" is defined as a semester hour, or its equivalent, from an "approved course provider."

Who is considered an "approved course provider" is also listed in the MOE provisions:

- An institution that has an EAC/ABET program.
- An institution or organization accredited by an NCEES-approved accrediting body. These may include regional accreditation bodies and other appropriate discipline accreditations. Such an institution or organization would be approved to develop and offer courses that meet the requirement of the MOE provisions.
- An institution or organization that offers specific courses that are individually cleared by an NCEES-approved accrediting body and that also meet the requirements specified under the MOE provisions.

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