Professional Licensure: The Core of the Civil Engineering Body of Knowledge

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Abstract

For the past 100 years, the professional engineer's (PE) license has been used by states to protect public safety and define the minimum knowledge needed to practice engineering, yet the debate continues about the importance of licensure, even within the engineering community. The debate has migrated into the political realm as local and state politicians question the importance and necessity of engineering licensure. One way to address this issue is to educate young engineers about licensure laws. The curriculums of fifty EAC-ABET accredited civil engineering programs in the United States were reviewed. Course requirements for a degree, capstone course descriptions, and professional topics courses that focus on licensure were examined. The survey revealed that fewer than half of the programs had a specific course focused on professional issues, most programs had a one-semester capstone course, and licensure was not a common topic in either the professional issues or capstone courses. As ASCE considers publishing a third edition of the Body of Knowledge (BOK), the profession should consider adding a new licensure outcome. A professional licensure outcome would influence both the cognitive and affective domains of an engineer's pre-licensure education and clarify that civil engineers must be knowledgeable of professional licensure laws and regulations prior to becoming a licensed professional engineer.

Introduction

The civil engineering profession has a very distinct skill set that must be obtained through education and experience. [1] The culmination of this process occurs when a state board presents a civil engineer with a professional engineering license. Licensure carries with it responsibility, liability, and privileges that are a very important part of the engineer's career. [2]

Licensed professional engineers are the cornerstone of the civil engineering profession. One of the intended goals of the licensure process is to protect public health, safety, and welfare. [3] It provides society with a verifiable reason to trust the profession and an assurance that licensed engineers possess the knowledge and experience to practice. Unlike their engineering colleagues who are employed in industries that assume product liability for their designs, engineers who offer professional services are regulated by state licensure boards, laws, and regulations. [4]

In most jurisdictions, the first step to licensure is to enroll in an accredited civil engineering program. In the United States, civil engineering programs are accredited by EAC-ABET, an organization consisting primarily of volunteers from the profession. [5] In recent years many state legislatures have influenced these programs by mandating that public universities require fewer courses to obtain a bachelor's degree in engineering. [6] [7] At the same time the civil engineering community, through the American Society of Civil Engineers (ASCE), created a Body of Knowledge (BOK) that specifically addresses the knowledge, skills, and attitudes that engineers should aspire to obtain prior to licensure. [1] These conflicting forces have placed external pressure on academic leaders that make critical curriculum decisions that affect their students.

In addition to educational struggles within the profession there are other factors that continue to challenge the licensure premise. Is licensure needed, does it violate antitrust laws, and is it really

effective at protecting the public? Today's reality is that civil engineers must justify the importance of licensure.

Background

Historical

One of the milestones in the engineering profession was the creation of the licensure process. In 1907, Wyoming was the first state to adopt a licensure law. [8] In the following decades every state and territory followed their lead and passed similar laws although all are unique. The laws were created to ensure the public's safety and formalize the minimum knowledge needed to enter the civil engineering profession in the United States. [9] [10]

State statutes define the practice of engineering, authorize a licensure board that oversees the process, and describe the requirements to become licensed. The process is entirely state run; there is no oversite from the federal government. Each state licensure board creates administrative rules to regulate the licensure process and the practice of engineering. Only the state can make changes to the statute and rules. [11] These boards, consisting of representatives from the profession and the public, are tasked with reviewing applications for licensure to ensure minimum standards are met and disciplining those that violate licensure laws and regulations. [8]

The civil engineering profession historically has had the highest percentage of licensed engineers. [12] Many job functions require a licensed engineer to seal documents and maintain responsible charge of projects. This trend continues today as over forty percent of civil engineers are registered. [13] Licensure has continually been associated with the protection of public health, safety, and welfare which aligns very closely with many of the functions of civil engineers. The ASCE and National Society of Professional Engineers (NSPE) codes of ethics support licensure and the concept that the civil engineering profession is tied to ethical practice through licensure. [14] [15]

Is State Licensure Necessary?

In recent years there has been a proliferation of licensure laws to regulate occupations. Because of the burden of these new regulations, the entire licensure concept is currently in question. A recent U.S. Supreme Court decision in *North Carolina Board of Dental Examiners v. FTC* limited a state licensure board's jurisdiction. The North Carolina Board of Dental Examiners issued cease and desist letters to teeth-whitening businesses that were not operated by licensed dentists. The court ruled that the state licensing board had violated anti-trust laws, thereby partially eroding the decades old State-action Immunity Doctrine that gave state licensing boards jurisdiction over the practice of their profession. [16] The court's decision empowered many state governments to reconsider which professions should be licensed and how licensing laws should be enforced. [17] While engineers may argue they have a long standing licensing tradition that is closely tied to public safety, there are groups that are opposing nearly all forms of licensure.

In 2014 the Indiana General Assembly formed a Jobs Creation Committee (JCC) to investigate the necessity of professional engineering licensure. The five person committee was initially in unanimous agreement that engineering licensure was not necessary and an economic burden for the state. Upon further investigation this position was repealed, but only after significant work educating the committee by the engineering community. [18]

In July 2015, the White House released a report on *Occupational Licensing: A Framework for Policymakers*. It concluded that one-quarter of U.S. workers must have a state license to do their jobs, a five-fold increase since the 1950s. While the article did not single out engineers, the report did question the necessity of licensure that did not provide health and safety protections to consumers. This outcome shows it is incumbent on the engineering profession to demonstrate the necessity of licensure to the public or face continued scrutiny. [19]

Others within the engineering profession have questioned the need for engineering licenses for most career paths. There is not universal agreement within the civil engineering profession on who should be licensed and how to apply licensure to specialty areas such as structural engineers or professors. [13] These questions continue to be debated as demonstrated by the topic of the 2017 ASCE Mead Paper Contest. [20] While this may seem like a new assault on licensure, the reality is it has been argued to various degrees since the inception of professional licensure. [21]

A strong argument in support of licensure is the National Council of Examiners for Engineering and Surveying (NCEES) Model Law and Model Rules that was authored and approved by representatives of state licensure boards. Section 110.10 of the Model Law explains their rationale for licensure as "In order to safeguard the health, safety, and welfare of the public, the practice of engineering…in this jurisdiction is…hereby declared to be subject to regulation in the public interest. The practice of engineering or surveying shall be deemed a privilege granted by this jurisdiction through the licensing board based on the qualifications of the individual as evidenced by that individual's certificate of licensure." [22]

Many state licensure laws are weakened by industrial exemptions for engineers. [4] Spinden argues that the industrial exemption to professional licensure is dangerous to the public, citing the 1986 Challenger tragedy and the 2010 Deepwater Horizon disaster as examples of "bad business decision masquerading as an engineering failure." [11] These disasters that were under the standard of care of unlicensed engineers demonstrate licensure is needed. A licensed professional engineer, exercising independent judgment, is less likely to allow management to make decisions that endanger public safety.

ASCE's Support for Licensure

ASCE has made organized efforts to define, promote, and protect engineering licensure through public policy statements related to licensure and government lobbying. [3] There are standing public policy statements on engineering education prior to licensure, obtaining experience prior to license, and engineering examination for licensure. [23] [24] [25] These statements make it very clear that ASCE directly supports the licensure process.

Over twenty years ago, ASCE initiated a process to strengthen the civil engineering profession by defining a body of knowledge (BOK) for engineering students and graduates. The first edition, BOK1, listed key outcomes in an attempt to define a more uniform educational and experiential process for those aspiring to licensure. The BOK1 was developed to promote the Raise the Bar Initiative and was updated in 2008 with the publication of BOK2. [26] [1] The BOK2 is defined as "…the necessary depth and breadth of knowledge, skills, and attitudes required of an individual entering the practice of civil engineering at the professional level in the 21st century." [1] More recently, NSPE paralleled ASCE's efforts by creating its own body of knowledge (EBOK) for professional engineers. The EBOK introduction states it "… is defined

as the depth and breadth of knowledge, skills, and attitudes appropriate to enter practice as a professional engineer, that is, licensed and in responsible charge of engineering activities that potentially impact public health, safety, and welfare." [27] Clearly both documents attempt to describe the knowledge that an engineer should attain through education and experience prior to licensure. [28] Licensure was created to help define the minimum knowledge needed to practice engineering, and the ASCE BOK was created to help formalize the profession's definition of knowledge prior to licensure.

The Licensure Process

Licensure is a three step process consisting of education, examination, and experience. In most jurisdictions, education begins when a student matriculates into an EAC-ABET accredited engineering program. A comprehensive computer-based fundamentals of engineering (FE) examination is taken near or at the end of the bachelor's degree program. Following graduation, civil engineers obtain qualifying experience and take an examination focused on the principals and practice of engineering, commonly referred to as the professional engineers (PE) exam. The FE exam is taken before the PE exam, but the time between the exams varies from state to state. The NCEES 2015 model law now allows engineering graduates to take the PE exam prior to completing their experience requirement and many states have adopted this policy. [22] The experience component varies from state-to-state, but is generally four years of experience under the responsible charge of a professional engineer following graduation with an EAC-ABET accredited bachelor's degree in engineering. Each of these steps plays a unique role in licensure, but engineering education is the beginning of the process.

Engineering Education

Engineering education is accredited by the Engineering Accreditation Commission (EAC) of ABET, Inc. They publish accreditation standards for engineering programs that are applicable at both public and private universities in the United States. Since the creation of ABET's founding organization, the Engineers' Council for Professional Development (ECPD), in 1932, one of their primary goals was to provide the "basis of quality against which professional engineers are held for licensure." [5] EAC-ABET consists of volunteers from member societies, such as ASCE, that conduct reviews and on-site visits of engineering programs to ensure that the ABET criterion are met. ABET recognizes civil engineering's close tie to licensure and reaffirms this within the Civil Engineering Program Criteria (CEPC) which requires that the "curriculum must prepare graduates . . . to explain the importance of professional licensure." [29] Civil engineering programs should have a curriculum that includes current licensure topics. [30] However, the international engineering community is not in agreement on the importance of licensure. The International Engineering Alliance (IEA), of which ABET is a member, has no graduate attributes that confirm the importance of licensure. [9]

The curriculum and organization of engineering programs are influenced by a number of different factors. Civil engineering course content changes over time. [31] ABET is one of the most obvious influences on the curriculum and programs continue to make changes in response to ABET changes. [32] The FE exam content serves as another influencing factor on curricular content in civil engineering programs. The civil engineering FE exam consists of 110 multiple choice questions in eighteen subject areas. One of the subject areas, Ethics and Professional Practice, includes licensure as one of six topics, but a student has less than a 1% chance of

encountering a licensure question on the exam. [33] Many programs use the FE exam for student outcome assessment, further connecting programs to the examination part of the licensure process. [12] Another critical factor is alumni feedback with regard to how the profession is changing and what content is critical and valued. Some programs rely heavily on practitioners to teach capstone and design courses within their curriculum to meet this goal. [34] As documented in the previous section, state legislatures have influenced curriculums by imposing credit hour degree limits at public universities. All of these factors have jointly caused a significant reduction in content in many civil engineering programs. [26]

The BOKs Impact on Civil Engineering Programs

The creation of the ASCE BOK was the first document of its kind for civil engineers in the United States and the outcomes were closely aligned with the EAC-ABET program outcomes. However, this changed when the BOK2 was published with an expanded number of outcomes in 2008. [35] The BOK2 influenced ABET, albeit indirectly, by leading to changes in the EAC-ABET civil engineering program criteria (CEPC). [36] The ASCE task force "Civil Engineering Program Criteria Task Committee" was organized in 2012. This committee compared the BOK2 outcomes with the CEPC criteria and found that numerous BOK2 outcomes were not met by the CEPC. [37] Their work led to proposed changes to the CEPC in 2014. The proposed CEPC changes were vetted by EAC-ABET and approved for the 2016-2017 accreditation cycle. [38]

One of the goals of the BOK was to influence the laws and rules of the 56 licensing boards. [23] Minimum education levels required for licensure are published by every state licensing board. ASCE's aspirational education levels (B + M/30) have been defined by the BOK2 outcomes. [37] These two driving forces are not currently in alignment because they establish two different education and knowledge levels for the profession.

As the discussion continues over how to implement BOK2 criteria into civil engineering curriculums, it is important to note that neither version of the BOK has a direct licensure outcome. The description of BOK2 outcome 24, "Professional and Ethical Responsibility," broadly refers to licensure, but it does not include the important components of licensure statutes and regulations such as the reasons for licensure, how the "practice of engineering" is defined, and the use of the engineer's seal. [1]

Confluence of Licensure and Education

Engineers are generally perceived as being technologically savvy, smart, and reclusive, but not society's leaders and communicators. The public's misunderstanding of the engineering profession resonates with many aspiring engineering students who enter college with a wide variety of perceptions of the profession. [39] Given this general low level of comprehension by the public, it is no surprise that engineering students have a limited understanding of professional licensure.

Can the civil engineering profession depend on accredited engineering programs to provide students with knowledge about licensure? The EAC-ABET civil engineering program criteria states that "the program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience." [29] Freidson states that those involved in educating candidates

for entry into the profession should possess the "qualifying credential," however, civil engineering faculty are not required to be licensed professional engineers to comply with the EAC-ABET civil engineering program criteria. [40] [29] ASCE is the professional organization responsible for the content of the EAC-ABET civil engineering program criteria. Canon 7 in ASCE's Code of Ethics states "Engineers should encourage their engineering employees to become registered at the earliest possible date." [14] If this canon is applied to EAC-ABET accredited civil engineering programs, there is an implied responsibility of civil engineering department heads to ensure that faculty who teach civil engineering design courses are licensed professional engineers. Licensed civil engineering faculty are knowledgeable about licensure laws and regulations and are better prepared to educate students about this topic.

Civil Engineering Curriculum Survey

A survey of 50 EAC-ABET accredited civil engineering program curriculums was conducted to create baseline knowledge of licensure education in programs. The programs included 31 public universities and 19 private universities from 30 different states. A spectrum of schools was selected including large and small civil engineering programs, research and teaching programs, and schools with and without a graduate program. The civil engineering curriculums were obtained from university web sites and published materials such as handbooks and undergraduate catalogs. Curriculums and course descriptions were examined to determine the extent to which these programs prepared their students to enter the civil engineering profession. Over three quarters of the universities reviewed are on a semester system. The average number of equivalent semester credits required to obtain a civil engineering degree was 128.5 for universities on a semester system. For those on the quarter system the number was 186.6 quarter credits (Table 1). These results are very similar to numbers reported by ASCE. [41]

Table 1. Survey of Civil Engineering Curriculums-Graduation Requirements

	Semesters	*Quarters*
Average number of credits to obtain a bachelor's degree	128.5	186.6
Number of schools using this system	38	7

Approximately fifty percent of the civil engineering programs had a specific professional issues course that was separate from the capstone design course. Twenty percent of the programs required students to take (but not pass) the Fundamentals of Engineering (FE) examination as a graduation requirement (Table 2).

Table 2. Survey of Civil Engineering Curriculums-Licensure Content

	Yes	*No*
Program includes a professional issues course?	24 (48%)	26 (52%)
Taking the FE exam is required for graduation?	10 (20%)	40 (80%)

The breadth of civil engineering capstone courses varied. Eighteen percent of the programs allow civil engineering students to select a design elective course among a menu of options (Table 3). These programs have a designated "design course" in each civil engineering discipline (structural engineering, geotechnical engineering, etc.) that meet this graduation requirement. The design courses are intended to meet EAC-ABET criterion 5. [29] The majority of programs required students to take a specific one semester capstone or design course (62%), and the remaining programs (38%) required all students to complete a specific two-course capstone design project (Table 4). The course descriptions of most two semester capstone courses included professional issue topics in the first course in the sequence.

Table 3. Capstone Courses in Civil Engineering Curriculums

	Specific Course	*Design Elective*
Capstone Course	41 (82%)	9 (18%)

Table 4. Number of Courses in the Capstone Sequence

	One course	*Two Courses*
Number of Courses in Capstone Design Sequence	31 (62%)	19 (38%)

Most programs include professional topics in some format either within the capstone sequence or a separate professional topics class. However, in the majority of these courses, licensure is a

minor topic in the course description. The small percentage of schools that require the FE exam for graduation further reveals that student knowledge of the licensure process is not a priority.

Using Knowledge of Licensure to Strengthen the Civil Engineering Profession

The taxonomic approach to professions distinguishes members of a profession by the diverse range of characteristics differentiating them from other occupations. [42] Freidson states that a profession exists through a specialized body of knowledge and licensing laws. [40] Ressler applied Friedson's third logic--the ideal-typical profession--to civil engineering and pointed out that a profession is defined by five interdependent elements, including a "qualifying credential." [43] Engineering licensing boards exist as a "filter" to ensure that those in the profession have the "qualifying credential"…a license to practice engineering. Freidson reasoned that "an essential characteristic of professionalism lies in…requiring candidates to pass some sort of examination in order to obtain their qualifying credential." For the civil engineering profession, one of the essential characteristics of its members is their personal commitment to obtain and maintain a professional license.

ASCE's emphasis on professional licensure is critical to the current and future strength of the profession. Freidson's model of ideal-typical professionalism, which includes a body of knowledge, could be used to guide the future strategic direction of the civil engineering profession. [44]

Incorporating Licensure in the ASCE Body of Knowledge

If licensure is the "qualifying credential" for the civil engineering profession, it is reasonable for licensure to be included in the BOK3. Although every state has different licensure laws and regulations, most states have similarities within their laws. Professional licensure topics common to all states could form the basis of a professional licensure outcome in a new BOK3. A licensure outcome could include:

- Definition of the practice of engineering
- Standards of practice
- Examination requirements
- Use of a seal
- Ethical, economic, and legal principles
- Direct supervision of other engineers
- Use of the word "engineer" in a job title
- Professional incompetence
- Unprofessional behavior and licensure violations
- Penalties
- Continuing education requirements for license renewal
- Comity, reciprocity, and specialized licensure

Knowledge of state licensure statutes and regulations is already required in some states that require licensees to complete a professional development hour on statutes and regulations to renew a professional engineer's license. [45] This regulatory content could easily be replicated and serve as a framework for a BOK3 licensure outcome. The licensure outcome could be

considered at Bloom's Level 4 which is comparable to BOK2 outcome 24, Professional and Ethical Responsibility. The result would be a better comprehension and justification for licensure laws and regulations.

Conclusion

The proliferation of occupational licenses has led politicians and state legislatures to question the need for professional engineering licensure. Questioning the licensure process is a reasonable public response, but not having an answer to legislative inquiry is a detriment to the engineering profession. Civil Engineers must be knowledgeable of licensure laws and regulations to defend licensure as a means of protecting public safety and a vital part of the minimum criteria needed to define the profession.

A survey of fifty civil engineering programs revealed that approximately fifty percent had a specific professional issues course in their curriculums. Most programs include professional topics within the capstone sequence, but it was a minor topic in the majority of these courses. Only twenty percent of the programs required students to take the FE examination to graduate. These findings indicate that student knowledge of licensure laws and regulations is not a high priority in the programs examined.

The ASCE Body of Knowledge is specifically written as a set of outcomes that define the knowledge, skills, and attitudes an engineer should possess prior to obtaining a professional engineering license. BOK2 outcome 24 focuses on professional and ethical responsibility but does not include knowledge and understanding of licensure laws and regulations. Adding a specific licensure outcome to the ASCE BOK3 would address distinct licensure issues. Placing more emphasis on licensure in undergraduate engineering programs will help students understand the close link between the civil engineering profession and state licensure laws that are intended to safeguard the health, safety, and welfare of the public.

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