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What Do First-year and Senior Civil Engineering Students Think About Raising the Bar on the Education Requirements for Professional Licensure?

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Abstract

While the civil engineering profession has endorsed "raising the bar" on the formal educational requirements for professional licensure, other engineering disciplines have opposed this change in part due to a concern that this change might reduce the number of students pursuing engineering degrees. This research presents the opinions of first year and senior civil engineering students on the potential requirement for a Master's degree or 30 additional coursework credits (M/30) prior to professional licensure. First year and senior civil engineering students attending a large, research-intensive public institution provided their feedback in fall 2015, 2016 and/or 2017. Among first-year students (n=81), 64% supported M/30 for professional licensure and 36% opposed it. Among civil engineering seniors (n=76), an in-class poll found that 16% felt that M/30 should be required for PE licensure in all disciplines, 38% felt M/30 should be required for PE licensure in civil and structural engineering but not all engineering disciplines, and 46% felt that M/30 should not be required for PE licensure. On a homework assignment, 13% of the seniors supported the change, 12% opposed it, and the remainder did not clearly state their personal opinion. Most seniors (85%) described beneficial reasons for the requirement for additional formal education. Fewer seniors (22%) discussed reasons in opposition to raise the bar (including some who did not make their personal opinion clear). The reasons for personal opposition included: higher cost to students and feeling that universities were just being greedy without a significant professional benefit to a Master's degree; feeling that real-world experience was more valuable than additional formal education; feeling that the change would introduce economic disparity and could decrease the diversity of licensed engineers. The results point to elements that should be considered when marketing raise the bar to engineering students.

Introduction

Engineers face challenging conditions in their work, which requires design for safety as well as the careful consideration of the needs of multiple stakeholders, potential environmental effects, and various risks and uncertainties. It is difficult to fully educate engineering students on both the breadth and depth of complex information and requirements that they will need to be ethical and effective practicing engineers within a Bachelor's degree. This is particularly true given that many Bachelor's degree programs in engineering are decreasing the number of credits required for their program, largely due to outside pressures related to college costs and helping students graduate within four years. This combination of forces led the American Society of Civil Engineers (ASCE) to propose that a Master's degree or 30 additional credits of coursework (M/30) should be required prior to professional licensure. This effort has been called "raise the bar", and an entire book summarizes the rationale [1].

The raise the bar initiative traces its roots to the Civil Engineering Education Conference in 1995, and formally began in 1998 when the ASCE issued Policy Statement 465 to describe their vision for the Academic Prerequisites for Licensure and Practice [2]. Thus, the vision of raise the bar is intimately tied to how to best prepare individuals to be competent and ethical professionally licensed engineers (PEs). Organizations outside the ASCE began formal involvement in 2000, when the National Council of Examiners for Engineering and Surveying (NCEES) formed its Engineering Licensure Qualifications Task Force, which included members from societies representing a range of engineering disciplines, including environmental, mechanical, and electrical. The National Society of Professional Engineers (NSPE) issued its own Policy Statement endorsing the concept of additional academic requirements prior to engineering professional licensure in 2002. The National Academy of Engineering (NAE) also acknowledged that future engineers would need education beyond a Bachelor's degree [3]. The ASCE, NCEES, and NSPE have continued actively updating and modifying plans and visions to ensure that professionally licensed engineers have strong qualifications. Each state licenses engineers, and may have differing requirements. To date, two state licensing boards have debated M/30: Vermont in 2015 [4] and New Jersey in fall 2016 [5]. No states have yet changed their requirements.

The American Society of Mechanical Engineers (ASME) has been the largest opponent to raise the bar. They host their own web site "licensing that works" to compile resources that oppose education beyond a Bachelor's degree as a pre-requisite for professional licensure [6]. In a 2010 ASME survey, 63% indicated that changes in the educational requirements for PE licensure were not justified [7]. The membership of the American Society of Agricultural and Biological Engineers (ASABE) also largely opposed M/30 (89.8% oppose, 8.8% for, 1.4% neutral; [8]). A 2012 position paper led by the ASME to oppose raise the bar [9] was endorsed by the American Institute of Chemical Engineers (AIChE), the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), the Illuminating Engineering Society (IES), Institute of Industrial Engineers (IIE), the International Society of Automation (ISA), Society for Mining, Metallurgy and Exploration (SME), the Society of Naval Architects & Marine Engineers (SNAME), the Minerals, Metals and Materials Society (TMS), and the executive board of the American Society for Engineering Education (ASEE) Engineering Deans Council. Each of the ten opposition points raised in the paper were addressed by Ressler [10]. The IEEE also issued a position statement opposing additional educational requirements for professional licensure [11]. Even among civil engineers, not everyone supports raise the bar [12].

One key argument for requiring a Master's degree or additional formal education prior to professional licensure is that the number of credits in engineering Bachelor's degrees in the U.S. has been decreasing while the body of knowledge required for engineers continues to expand. Nationally there has been a movement to reduce the number of credits for all degrees in order to help boost on-time graduation [13, 14]. Data indicates that the number of credits in civil engineering bachelor's degrees has been declining. Among 11 institutions, the semester credit hours associated with a civil engineering bachelor's degree declined from an average of 152 in 1925 (range 128-174.3) to an average of 133 in 1975 (range 120 to 180) and an average of 127 in 1998 (range 120-134)

[15]. In addition, the engineering content among five civil engineering programs was shown to have decreased by 12 to 32 credits between 1925 and 1998 [15]. Forbes et al. [16, 17] benchmarked top-ranked (per US News and World report) undergraduate engineering programs in 2013, and found that the number of credits varied across engineering Bachelor's degrees in different disciplines at 28 of 43 institutions. At one large public research-intensive institution, the number of credits for different engineering degrees ranged from 123 to 135 credits (unpublished data). The median across all 354 engineering degree programs was 129 credits (low 120); 128 in civil and mechanical engineering, 129 in chemical engineering, 132 in electrical engineering.

Another argument for raising the formal education requirements for the professional licensure of engineers is to bring it more on par with other professions. The professions of medicine and law require 8 and 7 years of formal education prior to licensure, respectively; pharmacy a minimum of 6 years; architecture, accounting, and occupational therapy 5 years [18]. As of 2015, all states require 150 hours of college credit before an individual can take the Certified Public Accountant (CPA) exam [19]. It has been noted that students fulfill this requirement in a variety of ways, many by taking a variety of online and/or summer courses while an undergraduate student [19, 20]. However, Menk et al. [19] note that those who have earned a graduate degree perform better on the CPA exam.

Another approach can be to make the licensing exam itself more rigorous or add specialty licenses or certifications onto the PE designation. The structural engineering license (SE) has taken this approach, where an SE license can be obtained after the PE by taking and passing a 16-hour exam [21]. The SE exam goes beyond the multiple-choice items on the PE exam, including "constructed response (essay) items. These responses are graded by teams of subject-matter experts using an agreed upon solution and scoring plan. Each response is graded by two subject-matter experts. A third expert is used when needed" [22]. This depth portion of the exam is a much more accurate way to test design-level knowledge than the multiple-choice or "alternate format" items on the NCEES FE and PE exams that are machine graded. As of 2015, 11 states had a form of SE licensure [21]. The ASCE and American Academy of Environmental Engineers and Scientists (AAEES) also offer a variety of additional specialty certifications [23, 24].

A related question is the extent to which engineers value professional licensure [25]. This seems to vary widely among disciplines, based on the number of individuals who take the PE licensing exams in different disciplines [26]. In disciplines such as civil and environmental engineering, there appears to be a high value placed on professional licensure [27-29]. Voices in support of licensure have also come from biomedical engineering [30], chemical engineering [31], mechanical engineering [32], electrical engineering [33], and software engineering [34]. Tracking licensure in different engineering disciplines is difficult, because only 23 states that have discipline-specific licensure, practice, title, or rosters [35]. At present, the value of an engineering license seems largely undermined by the industrial exemption [36, 37]. Spinden [36] characterized the industrial exemption as dangerous to both engineering and the public, but noted that it is fully entrenched and would be very difficult to change given large

opposition from industry. He states: “one of the biggest barriers to engineering’s achieving recognition as a bona fide profession is the industrial exemption. It necessarily has meant that management, not engineers, is in control of much of the engineering that occurs in the United States. It has significantly affected the attitudes of engineers working in industry by allowing them to avoid responsibility for their engineering and by requiring them to factor business principles into their engineering judgment.” [36, p. 683]. Disciplines like mechanical, chemical, and electrical engineering appear strongly in support of the industrial exemption [31, 38, 39].

Perhaps a fairly high percentage of civil engineers are already earning graduate degrees, and thus a requirement to possess a Master’s degree for professional licensure would not be overly burdensome. Some support for this idea can be found by comparing the statistics on the number of bachelor’s and Master’s degrees awarded in civil engineering (Table 1 based on ASEE data, [40]). This ratio has averaged 41% over the previous 10 years (comparing the number of Master’s degrees awarded in civil engineering to the number of Bachelor’s degrees awarded two years prior). By comparison, the average percentage in chemical engineering is 23% (although many students go straight to a PhD), mechanical is 32%, and electrical plus electrical/computing has increased from 64% in 2007/08 to 95% in 2015/16 [41]. However, a large percentage of Master’s degrees are awarded to international students (who don’t continue to practice in the US) as compared to Bachelor’s degrees; across all engineering disciplines, international students earned 9.6% of the bachelor’s degrees and 58.1% of engineering Master’s degrees (2015-2016; [40]). This means that the percentage of civil engineers practicing in the U.S. with only a Bachelor’s degree might be much higher that the data in Table 1 implies.

Table 1. Bachelors and Masters Degrees Awarded in CE and PE Examinees [40, 41]

Year	Civil Eng BS degrees	Civil Eng MS degrees	Civil Eng Doctoral degrees	% MS vs BS, 2 yr lag	NCEES Civil PE Exam Takers 1st time	NCEES Civil PE Exam Takers, all
2015-16*	11,464	4,818	820	39	9378	15356
2014-15	11,900	4,897	882	39	8691	14196
2013-14	12,333	4,958	817	40	8088	13862
2012-13	12,464	4,778	806	39		
2011-12	12,309	5,002	714	45		
2010-11	12,154	4,739	747	45		
2009-10	11,027	4,088	681	40		
2008-09	10,508	3,659	707	39		
2007-08	10,132	3,437	706	38		
2006-07	9402	3,368	770			
2005-06	8935	3,835	767			

* 50 fewer schools in ASEE dataset, may account for decline

The NSPE also supports raise the bar; its statement adopted in 2016 notes [42]:

> With the continuing rapid expansion of knowledge required to practice in the basic, as well as the many specialized areas of engineering, NSPE believes that additional engineering education, but not limited to formal academic education, beyond the four year ABET/EAC degree should be required to meet the formal preparation necessary

for the practice of licensed professional engineering.

One of the arguments opposing raising the bar on PE licensure is that fewer students would pursue engineering as a major and a career [9]. However, the author could find no actual data reporting how engineering students felt about the potential requirement for additional formal education beyond a Bachelor's degree to become a licensed PE. Swenty and Swenty [43] studied the curricula of 50 ABET-accredited civil engineering degree programs and concluded, "student knowledge of the licensure process is not a priority." (p. 9). Thus, it is unclear the extent to which civil engineering students are educated about the licensure process in their undergraduate education, and their opinions on potentially raising the bar. This research aimed to begin to answer that question. The opinions of first-year civil engineering students are of interest, since many of these students are still deciding whether or not they will persist in civil engineering versus changing to other engineering majors (perhaps where PE licensure is less important) or transferring out of engineering entirely. The opinions of senior students are also important, since they are more familiar with the Bachelor's curriculum and perhaps have had internships which give them ideas about the educational needs for responsible engineering practice. Civil engineering would not want to deter these students from pursuing PE licensure, which could impact their career trajectories.

Research Questions

RQ1. What do first year civil engineering students think about raising the bar on the formal education requirements for PE licensure?

RQ2. What do senior civil engineering students think about raising the bar on the formal education requirements for PE licensure?

Methods

This exploratory study was conducted using a convenience sample of students enrolled in required civil engineering courses at a large, research-intensive, public institution. For institutional context, all civil engineering majors at the institution are required to take the NCEES FE exam prior to graduation; this is also true for architectural engineering and environmental engineering, the two other ABET EAC accredited degrees offered by the department. The civil engineering department includes specialty areas in construction engineering & management, structural engineering, geotechnical engineering, environmental engineering, water resources engineering, and building systems. Given the heavy research focus of the program, only 14 among the 48 tenured/tenure-track and full-time instructors in the department are professionally licensed engineers. The institution as a whole offers a number of other ABET EAC accredited engineering bachelor's degrees; among these, only mechanical engineering requires students to take the FE exam prior to graduation. Chemical engineering recommends that its graduating seniors take the FE or GRE exam.

To answer RQ1, first-year student opinions were acquired in the context of an Introduction to Civil Engineering course, a required course in the first-semester. Early in the semester the students were introduced to the concept of professional licensing, and the knowledge, skills, and attitudes desired for professional engineers via the ASCE Body of Knowledge (BOK2) [44]. Within the ethics unit later in the course, the fifth part of the individual homework assignment was on professionalism (16 points within the 100 point assignment). This question had four parts: (a) list the typical steps to become a licensed PE, (b) discuss why licensure is important, (c) select five attitudes from within the ASCE BOK2 outcome 22 and discuss why important, and (d) do you think a Master's degree or 30 additional credits of coursework should be required for professional licensure? Why or why not? Part (d) is the focus of this inquiry. Students were pointed to four resources to support answering the professionalism part of the homework: the ASCE BOK2 (referred specifically to Figure 1 and pgs. 6-9 and 21-22 in [44]), the NSPE website [45], and sources from the ASCE Raise the Bar [46, 47]. The student homework assignments in fall 2015 and fall 2016 were graded by the standard graduate student teaching assistant (TA) for the course. In fall 2017, student responses to part (d) were examined and coded by the manuscript author using emergent, thematic coding methods [48].

To answer RQ2, senior student opinions were gathered in the context of a required 2-credit Professional Issues course. There were 56 students enrolled in the course in fall 2016 and 64 students enrolled in the course in fall 2017. The students were all classified by the university as seniors. Two students were also participating in the 5-year BS/MS program in civil engineering, and thus had already committed to earning a master's degree. Seventeen percent of the students were female. Seventeen (14%) of the students were also earning a minor in business. Other activities of the civil engineering seniors that might be of interest include: 80% had previously completed an engineering internship, 20% undergraduate research, 16% participated in Engineers Without Borders-USA. When asked about future plans (where multiple responses were acceptable), 53% were interested in a job related to construction engineering, 38% structural engineering, 32% water resources, 23% transportation engineering, 21% geotechnical engineering, and 15% environmental engineering; 41% graduate school.

To acquire senior students' opinions on increasing the formal education requirements for licensure, two methods were used. First, in-class polling was conducted. In-class polling questions were typically included during lectures as a means to increase student engagement and award attendance points. But in all cases, students could answer one among multiple available polling questions to receive attendance points or alternatively sign-in on a hard copy form to receive attendance points. Thus, participation in the particular polling question related to this research was optional. During an early lecture in the fall semester course, students were being taught about the ASCE BOK2 and the professional licensure process. Within this lecture, the idea of raise the bar was introduced. This included four slides with reasons in support of raise the bar (NAE statement [3], declining credits required for engineering BS degrees, competitiveness with international engineers, parity with other licensed professions, BOK2 outcomes mapped to BS, M/30, and experience) and one slide with reasons in opposition to raise the bar (five points from the ASME position statement [9]). Following this information, the students

were presented with an in-class poll. The poll asked students to select which statement best matched their opinion regarding raise the bar from among three options: (A) Yes, M/30 should be required for PE licensure in all disciplines; (B) Yes, M/30 should be required for PE licensure in civil and structural engineering but not all engineering disciplines; (c) No, M/30 should not be required for PE licensure. Among the 2016 class, 35 of the 56 students (63%) participated in the poll. Among the 2017 class, 41 of the 64 students (64%) participated in the poll. In 2017 only, a follow-up question on raise the bar was added as an in-class poll after the related homework assignment had been submitted.

The second method used to understand students' opinions was to use content analysis of student homework assignments. An early assignment in the semester directed students to read portions of the ASCE BOK2 [44]. The BOK2 was provided to the students within the online course learning platform, and designated as "required". Within the same learning module, students were also provided with Ressler's paper on raise the bar [10], which was also designated as "required." Two additional readings on raise the bar were provided to students in the online course learning system, but not designated as required: Russell et al. paper [15] that described the declining credits in engineering bachelor's degrees and the 2012 ASME position statement in opposition to raise the bar [9]. The homework assignment itself included six questions. The fifth question asked students to describe the process required to obtain a PE license. It also asked students to describe how the requirements for PE licensure might change in the future and how PE licensing requirements related to ethics. Students were instructed that their answer to this question should be about 300 to 500 words. The majority of the responses were within this range, although some were shorter. Some also failed to describe how PE requirements might change or discuss the links with ethics. In 2016, 54 assignments were submitted (from 56 enrolled students). In 2017, 61 assignments were submitted but two of those did not answer question 5 (thus 59 assignments could be examined among 64 enrolled students).

Content analyses of the assignments for this research to explore students' perceptions of raise the bar were completed after the end of the semester or after the assignments were graded, and thus had no grade impacts for the students. First, it was determined if the student response acknowledged that M/30 was a potential future change in the PE licensing requirements. If yes, the response was then explored to determine if the student stated a personal opinion about this change, either in support or opposition. Finally, the response was examined to explore if the student discussed any positive or negative aspects of this change. These responses were further grouped into emergent themes per standard qualitative research methods [48].

A third source of convenience data was used to provide context to the results. The College of Engineering administers a survey to all graduating seniors each term. Questions on the survey for civil engineering majors ask them their perceived importance of professional licensure in their future careers. Questions for all majors ask about post-graduation plans in terms of graduate studies and certainty that they will pursue a career in engineering. These responses provide some additional context to the data from the senior students.

Results

First-Year Students – Homework

Among the 81 students in the first-year (FY) introductory course who completed the homework assignment, 64% (n=52) supported the idea that a Master's degree or 30 additional coursework credits be required as a condition for professional licensure. There was not a significant difference between the responses in 2016 (n=45, 67% support) and 2017 (n=36, 61% support). Among the 25 female students in the course, 72% supported M/30 for licensure. A limitation that should be considered when interpreting the data is that due to the graded assignment, a student might feel pressured to agree, believing this to be the more socially-acceptable answer (given that the majority of the references provided by the instructor with the assignment were in support of raise the bar). One student response alludes to this, being prefaced by, "I know I may be looked down on for this answer, but no, I do not believe that a person should be required to earn a master's degree…."

The primary reasons that students supported raise the bar are summarized in Table 2. Most cited the need for more knowledge, due to advances and changes. Among these, many also included the decreased credits in a Bachelor's degree. A second theme that was common was that a Master's degree would help to ensure proper protection of human and environmental safety/welfare. Most of these individuals had previously discussed knowledge. Finally, a few cited issues related to prestige. That a PE should be respected beyond those practicing with a Bachelor's degree. A similar percentage of the female students cited these same reasons in support of raise the bar as the students overall. Interestingly, one student stated an opposing view to the prestige claim, stating "I think if a masters becomes required it will lose some of its prestige and significant qualities."

Table 2. Reasons students cited in support of raise the bar

Theme	% FY (n=52)	% Seniors (n=84)	Example Student Quote
Required to gain necessary knowledge	87	50	Yes I do think a master's degree or 30 additional credit hours should be required to get a professional license. The knowledge required to be a civil engineer in these modern times is greater than what one can learn in the 4 years of an undergraduate degree. Engineers need a greater depth of knowledge that can only be gained through a master's degree
Important to ensure public safety / welfare	46	57	I think that more expertise and knowledge should be required for professional licensure. I think that engineers need to be as educated as possible, so that they have the skills necessary to keep the public safe
BS inadequate, declining credits	21	29	The number of credits required for a professional license has declined over the years and I think that a Master's degree or 30 more credits should be required. Advancing education is huge and I think we have to go beyond the four years to gain more knowledge since we are getting a professional license. There's so much more to learn other than the basics.

Theme	% FY (n=52)	% Seniors (n=84)	Example Student Quote
Prestige	17	7	Yes, I believe that a master's degree or 30 additional credits should be required for a professional licensure otherwise the licensure wouldn't be as prestige. A license should be a special honor to an engineer
Necessary for specialization	15	37	The idea behind this change is that all professional engineers would have more technical breadth and specialization due to the Masters degree. During a Masters program, the students mainly focus on obtaining more experience with problem solving, design and technical specialization. All three of these are important aspects of working as a civil engineer….
Alignment with other professions	4	12	many other professional careers require higher requirements in order to keep up with the safety and government standards, engineers should be just as qualified so that they can act responsibly in any situation whether with a company or with a customer

Coding the responses for why students opposed the M/30 requirement, five primary themes emerged, as summarized in Table 3.

Table 3. Major reasons for opposition to M/30 requirement

Theme	% FY (n=29)	% Seniors (n=22)	Example Student Quote
Work experience more valuable	62	14	I do not think that a master's degree should be required for professional licensure, because you can gain just as much, or even more knowledge about engineering through actual work experience. Many people learn best by doing, and in a job or internship, you can get all the experience and knowledge you need
Process OK now	34	32	I do not think that a master's degree should be required for professional licensure. A lot of training is done through the path to professional licensure in the four years spent under a professional engineer. This is a time for intense, on-the-job learning that can only be accomplished working in the field. This kind of work cannot be done in school, and many successful engineers have made it to very successful, ethical careers without a master's degree
Cost of additional education	24	32	I don't think it is a good idea that 30 hours of coursework or a master's degree be required for a professional licensure, since these programs can often be expensive, which would price many competent engineers out of the realm of competition for a PE
Discourage engineers from becoming licensed	10	18	I think that requiring M/30 would restrict a lot of qualified engineers from practicing as a PE … it is wrong to assume that someone is poorly educated just because they didn't pay to go to school for another two years. I don't think the solution to poor engineering practice is to send people back to school
Discourage students from pursuing engineering	7	23	raising the bar will decrease the United States global competitiveness in the fields of science, technology and engineering because of a potential decrease of the number of engineers or students entering into engineering

The majority discussed how they believed that work experience was more important than additional formal education. Many also described that they felt that the current process for

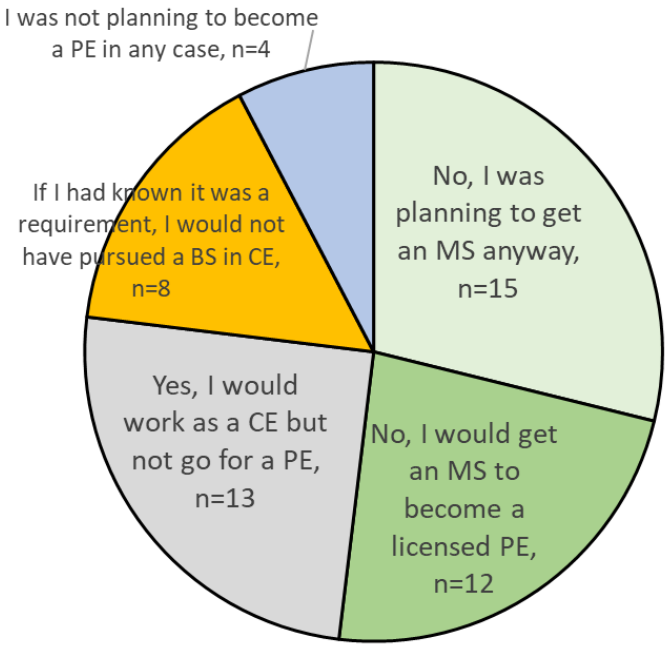
licensure was sufficient, with a combination of an exam, formal education from a Bachelor's degree, and practical experience. Some elaborated that if one can pass the exam that should be sufficient evidence of competence, and another indicated that the exam could be made more rigorous if individuals were uncertain that the current requirements were sufficient. This would provide flexibility for an individual to teach themselves the necessary information. Some discussed the cost of formal education as a deterrent (although not typically as their sole reason for opposition). Only a few believed that the M/30 requirement would discourage engineers from pursuing licensure or that the M/30 requirement would discourage students from majoring in engineering. Among the female students in the course who were against raise the bar (n=7), 57% noted that work experience was more valuable, 43% felt that the process was sufficient now, and 14% cited cost concerns. Two of the students who ultimately supported the M/30 requirement did cite negatives, including the cost and "it may make the job of a Civil Engineer less desirable in some aspects, but the benefits rule out the negatives."

Senior Students - In-class Poll

Among the 76 responses to the in-class poll on raise the bar, 16% felt that M/30 should be required for PE licensure in all disciplines, 38% felt MS/30 should be required for PE licensure in civil and structural engineering but not all engineering disciplines, and 46% felt that an M/30 should not be required for PE licensure. There were not differences in these responses between the 2016 and 2017 students; 46% opposed in 2016 and 46% opposed in 2017. Similarly, among the sub-set of 57 students who had completed an internship and answered the in-class poll, 46% opposed the requirement for M/30 for PE licensure. Among only 13 female students who responded to the in-class poll, 38% opposed M/30. The M/30 opposition among the seniors at 46% was higher than among the first-year students at 36%.

A week after completing the homework assignment that included raise the bar, students in fall 2017 were asked during lecture to respond to the following question: *If getting a PE license in civil engineering began to require a Master's degree, would it deter you?"* The multiple-choice response options and responses are shown in Figure 1. The results are somewhat "gloomy", with just over half indicating that an MS degree requirement for PE licensure was not a deterrent. Among the 7 female respondents, 5 (71%) responded that they were planning to get an MS anyway, 1 (14%) that she would get an MS to become a licensed PE, and 1 (14%) that she was not planning to become a PE in any case.

Figure 1. Senior student responses to the in-class poll question "*If getting a PE license in civil engineering began to require a Master's degree, would it deter you?"*



Among the eight students who would not have pursued a BS in civil engineering if it was a requirement to have a Master's degree, four were primarily interested in structural engineering and four in construction engineering after college. In addition, seven had previously worked at an internship. Three had in fact been informed about the potential for M/30 requirement for licensure as first year students when they took the Introduction to Civil Engineering course in fall 2015 (as described previously). The others may have transferred into the program and therefore taken a general introduction to engineering course offered by the college that does not discuss licensure, or had taken the Introduction to Civil Engineering course from an architectural engineering faculty member in 2014 who did not discuss potential changes to the licensure requirements.

The seniors indicating that they were not planning to get a PE "in any case" also deserves further discussion. Among the four students indicating this, three were interested in a construction engineering job after graduation. A large percentage of the civil engineering majors at the institution are primarily interested in the construction engineering & management side of the discipline. These students receive various messages about the importance of PE licensure from their internship experiences and faculty. Within the civil engineering department at the institution, only 14 of 48 faculty have a PE license, which does not communicate a particularly strong message around the importance of licensure.

The graduating senior survey (which typically has over 90% participation) asks students, "How important do you think it is to be a professional licensed engineer (PE) for your long-term career aspirations?" The response scale options are: 1 – not at all important, 2 – not very important, 3 – moderately important, 4 – very important, 5 – extremely important. Results are summarized in Table 4. The only student in 2016-2017 to state that becoming a PE was not at all important indicated that their planned occupation after graduation was military, and also indicated they were "not at all certain" they would stay

in engineering as a career. The student from 2014-2015 indicating that a PE was not at all important indicated on another part of the survey that they were entering a career as a teacher. Among the 2016-2017 respondents, there was a moderate correlation between importance of PE ratings and certainty they would stay in engineering as career (correlation factor 0.347 in 2016-2017). This indicates that those who were the most confident of remaining in engineering for their career also placed the most importance on becoming a PE.

Table 4. Civil engineering student opinions on the graduating senior survey

Year	Average	n	Perceived importance of PE license for career, %				
			1 Not at all	2	3	4	5 Extremely important
2014-2015	3.87	60	2	10	23	30	35
2015-2016	4.02	60	7	2	22	23	47
2016-2017	3.78	50	2	12	28	22	36

The senior survey also asked if students planned to attend graduate school immediately; among the 2016-2017 civil engineering seniors, 22% had already applied and/or were participating in the BS/MS program. Write-in comments (n=8) on factors that influenced their decision revolved around needs for a graduate degree in their desired focus of structural engineering (n=4). For example, “In the structural engineering field, more firms are requiring a Master's degree as part of the primary qualifications for each position. Would have trouble finding the perfect job without a Master's.” Faculty and local employers send a strong message to these students than an MS degree is needed for those hoping to work in the area of structural design. Only two other sub-disciplines were specifically mentioned, geotechnical and environmental/international development. This indicates that different sub-fields of civil engineering may have different aspirations toward graduate degrees and/or professional licensure.

Senior Students - Homework Assignment

The homework assignment on the BOK2 was used to provide more insight into senior students’ opinions on M/30. Usage logs in the online course management system showed that all of the seniors had accessed the BOK2 prior to submitting the homework assignment. In addition, 29% accessed the 2012 ASEE paper on raise the bar by Ressler [10]. In 2017, 13% also/alternatively accessed the opposition to raise the bar report from ASME [9] and 13% also/alternatively accessed the 2000 paper by Russell et al. [15] that described the declining credits in engineering bachelor’s degrees. (Access to these documents by the 2016 students could not be determined.)

In their responses to the question on professional licensure, the majority of the students (88%) discussed that the requirements for licensure may change to require a Master’s degree or 30 credits of additional coursework. Among the 99 students that acknowledged this potential change, 13% seemed to support raise the bar, 12% opposed it, and the remainder did not comment on their personal opinion.

Two example quotes from students in support of raise the bar were:

> I believe that because of the implications (human lives) of engineering work, a master's degree should be required to become a P.E. This process of more rigorous licensure would ensure that engineers uphold their fundamental responsibility. (2016 male student with previous internship experience, post-graduation plans to work in construction engineering)

> … additional education should be implemented…. I do believe not enough is learned in a particular field to become a valuable engineer. (2017 Hispanic male student, internship experience, post-graduation interest in construction or water resources related job)

Those opposed to requiring M/30 prior to licensure described different reasons for this personal opposition: feelings that the current process was sufficient (n=4); feeling that real-world experience was more valuable than additional formal education (n=4); higher cost to students and feeling that universities and/or state licensing boards were just being greedy without a significant benefit to a Master's degree (n=3); feeling that there would be economic disparity in ability to afford a master's degree thus PE licenses only for wealthy and a decrease in diversity (n=2). An example quote related to the diversity issue is:

> Requiring a Master's degree also feels wrong to me. This is already an expensive, elitist degree and that's not a good thing; diversity brings so much to the table! If a Master's is required more people will be discouraged and more people won't have the time or money to become an engineer even if they would be really good at it. More school does not necessarily make a better engineer. I understand the need to protect what's around us and I appreciate the effort, but I do not think that we are headed down the best track to do that. (2016 female student, previous internship and study abroad experiences, interest in construction engineering job after college)

One felt there was too much breadth required in a civil engineering Bachelor's degree and that sufficient depth of technical knowledge was possible by redesigning the bachelor's experience:

> I believe that rather than extending the necessary schooling, we should restructure the civil engineering degree. Actually, I believe we should break it up so you cannot get a degree in civil engineering because it is too broad. Most civil engineering students have a preferred field within civil, so why not let them study that field thoroughly and disregard some of the courses that aren't necessary for proficiency in that field? (2017 male student, previous internship experience, interested in a structural engineering job after graduation)

Another student felt that changes in the Bachelor's degree could accomplish the BOK2 outcomes, including increasing pre-requisite knowledge before college:

> It is hard to argue with increased education, but what we need is more engineers, not fewer. This could help if there were better structures for engineering technicians in place, so that much of the leg work could be accomplished for engineering. It may be beneficial to just increase the accreditation requirements for a bachelor's in

> engineering. It is also likely that much of what is taught in early basics of science and math should be taken into high school levels, so perhaps starting engineering training earlier rather than extending it later would be more beneficial in the long run. (2017 male student, interest in water resources or transportation related job after college)

Regardless of their personal feelings, most students (86%) described reasons that supported raising the formal educational requirements for licensure. A much smaller number (21%) stated reasons in opposition to raise the bar. Only 15 students (15%) cited reasons that both supported and opposed the change. The themes in support and opposition for raising the bar were similar to those voiced by the first year students, and are summarized in Tables 2 and 3. Among the seniors, most cited ensuring human health and welfare (via sustainability, etc.) as a reason for requiring M/30, followed by more generally that an M/30 would provide the necessary knowledge to be a PE. The largest difference compared to the first-year students was the seniors discussing that specialized knowledge from M/30 was needed. These seniors had experienced more of the curriculum and many had internships, which perhaps enabled them to personally identify a gap in their feelings of preparation for practice in a particular area of civil engineering.

Discussion

The results do raise some concerns for how students might react to a change that requires M/30 as a prerequisite for professional licensure. It is believed that careful education around the issue could diffuse a number of student concerns. Among the first-year students some appeared confused about the timing of the additional educational requirements, perceiving that the Master's degree or 30 credits of additional coursework were needed before any work experience that counted toward licensure. This would be a greater deterrent, particularly for those already going into debt to receive a BS degree. If students had a better understanding that they could work as an engineer intern (EI) prior to additional education beyond the BS, this may alleviate some concerns. Further, students could be better informed about opportunities to take courses while working, and that some employers pay for these courses. Among the seniors, some seemed burned out on coursework and being full-time students, while others may not have earned grades that would typically gain admittance to graduate school (3.0 or higher at our institution). For example, in describing the path to PE licensure on senior stated, "The process begins with the grueling and expensive Bachelor's degree schooling experience." Therefore, it is important to make students aware of the various paths available to meet the +30.

Another issue was that some students need a greater understanding of licensure itself. Some first-year students did not recognize that one works as an EI making good money prior to PE licensure. This is particularly important given that many other engineering disciplines do not emphasize the importance of PE licensure. Students may opt out of civil engineering and into other disciplines if they perceive that their path to working as a civil engineer requires passing two exams (FE and PE) and M/30 that other engineering disciplines do not require. So more clear communication on these issues is important.

Clearly outlining the necessity for requiring an M/30 prior to professional licensure will be important. The reasons that students used in their writings may provide insight into the arguments that they found most compelling. It is important that this message comes from industry and practicing engineers rather than academia. A number of the seniors used language that reflected their belief that the M/30 requirement was motivated by greedy universities. Some students proposed changes in the BS degree or changes in the PE exam that could ensure competency. There should be evidence presented that these options were tried and found to be unsuccessful. There was certainty support for the "30" rather than a Master's degree as the sole method to achieve necessary knowledge to be a competent professional engineer. Industry may want to consider how it can bring this training to the workplace. One student wrote, "I feel that an additional 30 hours of coursework is necessary, but there should be ways to obtain it other than going back to school. I feel that companies should offer these courses as part of long term job training, to encourage employees to stay with companies for a longer time and also to learn the things needed for real world use, not academia use." Thus, some students believe that a research-focused graduate degree is of less use than more practically-focused courses.

It is unclear the extent to which the senior students felt pressure to "agree" with ASCE's position on the graded homework (where 85% cited reasons in support of raise the bar) versus were more honest in their polling answers (about half opposed). The homework prompt for the seniors did not explicitly require them to state support or opposition to M/30, unlike the in-class polling question and the homework for the first-year students. Because the first question on the homework assignment for the seniors had them map their courses and co-curricular experiences onto the 24 BOK2 outcomes for each level of achievement, some seniors may have realized that they did not meet the BOK2 requirements for licensure in their bachelor's degree and were thus more open to M/30.

The higher opposition to M/30 among the senior students versus first-year students (46% vs. 36%) may have been due to burnout with school among some of the seniors. The burnout characteristics of exhaustion and cynicism among college students have been linked with external regulation [49]; the M/30 requirement would be an extrinsic motivation to pursue graduate school. More research is needed to explore burnout characteristics among engineering students, correlations with rank, and links with graduate school motivation.

Summary

More of the first-year civil engineering students as compared to the seniors were open to the case that an M/30 was part of the appropriate path to professional licensure. Among first year students, 64% supported the M/30 requirement for professional licensure, compared to 54% support among seniors. The primary reason for support among the first-year students was the necessity to gain sufficient knowledge; half of the seniors also cited this reason, as well as M/30 being important to protect human safety and welfare. The primary reason for opposing M/30 among the first-year students was that they felt work experience was more important; among seniors, many felt that the current PE process was sufficient and also opposed M/30 due to the cost to individual engineers.

Change is often a difficult and slow process. Some individuals are comfortable with the status quo for the engineering professional licensure process, and fearful that changes could cause negative impacts (e.g. decreased enrollment in engineering programs, decrease in individuals pursuing licensure). However, the primary motivation should be ensuring that engineers are adequately prepared to meet the challenges of the future, able to make the best decisions for protection of human health and the environment. The current generation of students are the engineers of the future. Thus, introducing them to the notion of changing the pathway to licensure by requiring a Master's degree or 30 additional credit hours of coursework seems to be an appropriate investment. Further, these students can provide insights into potential enrollment impacts that implementing M/30 might cause.

Most first year students were learning about the professional licensure process for the first time, and thus M/30 was not necessarily perceived as a "change" but rather an introduction to the idea and rationale. The Body of Knowledge is likely an important educational tool to make the case for M/30, illustrating what knowledge gained through additional formal education beyond the Bachelor's degree is critical for practice as an engineer at the professional level. Careful discussion of the reasons for the change should decrease opposition. As well, employers can support the process and perhaps provide ways for their engineers to reach the 30 additional units of education while still working. Offering online education options for earning a Master's degree may also be attractive. Providing flexibility to working engineers to find a way to best meet their personal educational goals seems important. In this manner, increased education of professionally licensed engineers will benefit the individual engineers, their employers, and society as a whole.

References

[1] J.S. Russell and T.A. Lenox, Raise the Bar: Strengthening the Civil Engineering Profession. Reston, VA: American Society of Civil Engineers, 2013.

[2] J.S. Russell and T.A. Lenox, "The Raise the Bar Initiative: Charting the Future by Understanding the Path to the Present – An Overview," in *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference & Exposition, San Antonio TX, June 10-13, 2012*. Washington DC: ASEE, Paper AC 2012-3048, 2012. 72 pp.

[3] NAE, National Academy of Engineering, *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. Washington DC: National Academies Press, 2005. 208 pp.

[4] C. Ort-Mabry, Vermont PE Board Considers Raising the Bar for Civil Engineers. 2015. Available: http://news.asce.org/vermont-pe-board-considers-raising-the-bar-for-civil-engineers/. [Accessed Nov. 4, 2017].

[5] D. Soukup, P.E., Master's Degree Education Requirement Proposed in New Jersey. Posted Aug. 16, 2016. Available: https://community.asme.org/ltw_-_licensing_that_works/default.aspx. [Accessed Dec., 22, 2017].

[6] ASME, American Society of Mechanical Engineers, Participant-Created Group: Licensing That Works. Available: https://community.asme.org/ltw_-_licensing_that_works/default.aspx [Accessed Dec. 22, 2017].
[7] ASME, "Survey from ASME," *Mechanical Engineering Magazine,* Feb. 2010, pp. 4. Available: https://community.asme.org/ltw_-_licensing_that_works/m/mediagallery1/default.aspx. [Accessed Dec. 22, 2017].
[8] M. Crossley, "The Membership Has Spoken: Do Not Support the BS+30 Requirement for PE," *Resource*, May/June 2013. p. 31.
[9] ASME, *Mandatory Educational Requirements for Engineering Licensure*. General Position Paper Approved by ASME Feb. 16, 2012. Endorsed by: AIChE, ASABE, ASPE, ASHRAE, Executive Board of ASEE Engineering Deans Council, IES, IIE, ISA, SME, TMS, and SNAME. 5 pp.
[10] S.J. Ressler, "To Raise the Bar or Not: Addressing the Opposition," in *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference & Exposition, San Antonio, TX, June 10-13, 2012*. Washington DC: ASEE, Paper AC 2012-3972, 2012. 23 pp.
[11] IEEE-USA, *Position Statement: Educational Requirements for Engineering Licensure*. Adopted by IEEE-USA Board of Directors, 12 Feb. 2016. 1 pp. Available: https://ieeeusa.org/wp-content/uploads/2017/06/Licensureeducation0216.pdf. [Accessed Dec. 22, 2017].
[12] Protesting ASCE's Raise the Bar Initiative. Thread730-366540. 15 June 2014 to 17 Jul 2015. Available: http://www.eng-tips.com/viewthread.cfm?qid=366540. [Accessed Oct. 30, 2017].
[13] N. Johnson, L. Reidy, M. Droll, and R.E. LeMon, *Program Requirements for Associate's and Bachelor's Degrees: A National Survey*. Washington DC: Complete College America, 2012. 48 pp.
[14] N. Johnson, *Three Policies to Reduce Time to Degree*. Washington DC: Complete College America, 2011. 6 pp.
[15] J.S. Russell, B. Stouffer, and S.G. Walesh, "The First Professional Degree: A Historic Opportunity," *Journal of Professional Issues in Engineering Education and Practice*, vol. 126, pp. 54-63, 2000.
[16] M.H. Forbes, A.R. Bielefeldt, J.F. Sullivan, and R.L. Littlejohn, "Divergent Requirements for Technical and Non-Technical Coursework in Undergraduate Engineering Programs," *International Journal of Engineering Education*, vol. 33(1A), pp. 162-174, 2017.
[17] M.H. Forbes, A.R. Bielefeldt, J.F. Sullivan, and R.L. Littlejohn, "Low-Choice Culture in Undergraduate Engineering and Autonomy-Supportive Exceptions," *Journal of Professional Issues in Engineering Education and Practice,* vol. 144(1): 04017012, 8 pp, 2018.
[18] K. Fridley, "What is a BOK? What is the CE BOK?" Presentation at the ASCE Civil Engineering Body of Knowledge 3 Workshop. Aug. 5-6, 2016.
[19] K.B. Menk, B.M. Nagle, and S.E. Rau, "Does Earning a Graduate Degree Impact CPA Exam Performance?" *Academy of Business Research Journal*; Gulfport, vol. 1, pp. 27-42, 2017.
[20] J.M. Larkin, "The 150-hour Requirement for CPA Licensure: One Institution's Response," *American Journal of Business Education*, vol. 7(4), pp. 307-314, 2014.

[21] J. Landers, "Structural Engineering & Licensure," *Civil Engineering*, April, pp. 60-65, 2015.
[22] NCEES, National Council of Examiners for Engineering and Surveying. SE Exam. Available: https://ncees.org/engineering/se/. [Accessed Nov. 7, 2017].
[23] ASCE, American Society of Civil Engineers. Professional Certifications. Available: http://www.asce.org/professional_certifications/. [Accessed Dec. 22, 2017].
[24] AAEES, American Academy of Environmental Engineers & Scientists. Board Certification Programs. Available: http://www.aaees.org/becomeboardcertified/. [Accessed Dec. 22, 2017].
[25] J. Patterson, "Engineers should take a skills proficiency test," *The Johns Hopkins News-Letter*, Nov. 9, 2017. Available: http://www.jhunewsletter.com/2017/11/09/engineers-should-take-a-skills-proficiency-test/. [Accessed Nov. 10, 2017].
[26] NCEES, National Council of Examiners for Engineering and Surveying. *Squared*, 2016. Available: https://ncees.org/wp-content/uploads/Squared-2016.pdf. [Accessed Dec. 22, 2017].
[27] ASCE, *Policy Statement 130 – Professional Licensure of Engineers*. Adopted July 29, 2017. First approved pre-1974. Available: http://www.asce.org/issues-and-advocacy/public-policy/policy-statement-130---professional-licensure-of-engineers/ [Accessed Dec. 22, 2017].
[28] ASCE, *Guidance on Licensing and Ethical Responsibilities for Civil Engineers*. Reston VA: ASCE, 12 pp. Available: https://www.asce.org/uploadedFiles/Education_and_Careers/Licensure/Content_Pieces/licensing-ethics-brochure.pdf. [Accessed Dec. 22, 2017].
[29] American Academy of Environmental Engineers, *Environmental Engineering Body of Knowledge*. Annapolis MD: AAEE, 2009. 82 pp.
[30] J. Goldberg, "Professional Licensure of Biomedical Engineers," *IEEE Pulse*, vol. 8 (2), pp. 42-44, 2017. DOI: 10.1109/MPUL.2016.2647103.
[31] AIChE, AIChE Affirms Strong Support for Both Licensure and the Industrial Exemption. May 7, 2014. Available: https://www.aiche.org/about/press/releases/05-07-2014/aiche-affirms-strong-support-both-licensure-and-industrial-exemption. [Accessed Dec 22, 2017].
[32] ASME, American Society of Mechanical Engineers. *Society Policy. P-15.2 Engineers' Licensing*. 2/15/15. Adopted April 6, 1936. Revised Feb. 12, 2015. 3 pp.
[33] IEEE-USA, *Position Statement: Engineering Licensure*. Adopted Aug. 3, 2015. Available: https://ieeeusa.org/wp-content/uploads/2017/02/EngineeringLicensure0815-1.pdf. [Accessed Dec. 22, 2017].
[34] P.A. Laplante, "Safe and Secure Software Systems: The Role of Professional Licensure," *IT Pro*, pp. 51-53. 2012.
[35] C.N. Musselman, S. Kumar, N.J. Mattei, and L.R. Smith, "Licensure Issues of Strategic Importance to the Civil Engineering Profession – and ASCE," in *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference & Exposition, New Orleans LA, June 26-29, 2016*. Washington DC: ASEE, Paper ID #14392, 2016. 9 pp.
[36] P.M. Spinden, "The Enigma of Engineering's Industrial Exemption to Licensure: The Exception that Swallowed A Profession," *UMKC Law Review*, vol. 83(3), pp. 637-

686, 2015. Faculty Publications and Presentations. Paper 72. Available: http://digitalcommons.liberty.edu/lusol_fac_pubs/72. [Accessed Dec. 22, 2017].
[37] S.J. Ressler, "Sociology of Professions: Application to the Civil Engineering "Raise the Bar" Initiative," *Journal of Professional Issues in Engineering Education and Practice*, vol. 137(3), pp. 151-161, 2011.
[38] ASME. 2014. Industrial Exemption. Available: https://www.asme.org/wwwasmeorg/media/ResourceFiles/AboutASME/Get%20Involved/Advocacy/Policy-Publications/PS14-07-Industrial-Exemption-5-7-2014Statement.pdf. [Accessed Dec. 22, 2017].
[39] W.L. Elden, First-Hand: Challenges IEEE Faced Supporting Ethical Behavior and Professionalism. Revised Oct. 14, 2015. Available: http://ethw.org/First-Hand:Challenges_IEEE_Faced_Supporting_Ethical_Behavior_and_Professionalism. [Accessed Dec. 22, 2017].
[40] ASEE, American Society for Engineering Education. Engineering by the Numbers and Data Mining Tool. Available: https://www.asee.org/papers-and-publications/publications/college-profiles#Datamining_Tool [Accessed Dec. 2, 2017].
[41] NCEES, National Council of Examiners for Engineering and Surveying. Annual report and Squared. Available: https://ncees.org/about/publications/past-annual-reports-squared/ [Accessed Dec. 2, 2017].
[42] NSPE, National Society of Professional Engineers, *NSPE Professional Policy No. 168. Engineering Education Requirements*. Adopted 2002. Latest revision June 2016. Available: https://www.nspe.org/resources/issues-and-advocacy/professional-policies/engineering-education-requirements. [Accessed Dec. 22, 2017].
[43] M. Swenty and B.J. Swenty, "Professional Licensure: The Core of the Civil Engineering Body of Knowledge," in *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference & Exposition, Columbus OH, June 24-28, 2017*. Washington DC: ASEE, 2017. Paper ID #19425. 14 pp.
[44] ASCE, American Society of Civil Engineers. 2008. Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future. Second Edition. ASCE, Reston VA. 191 pp.
[45] NSPE, National Society of Professional Engineers. How to Get Licensed. Available: http://www.nspe.org/resources/licensure/how-get-licensed. [Accessed Dec. 22, 2017].
[46] ASCE, American Society of Civil Engineers. Raise the Bar. Available: http://www.asce.org/raise_the_bar/. [Accessed Dec. 22, 2017].
[47] ASCE, American Society of Civil Engineers. Raise the Bar for Engineering. Available: http://www.raisethebarforengineering.org/voices-support. [Accessed Dec. 22, 2017].
[48] J. W. Creswell, *Qualitative Inquiry & Research Design: Choosing Among Five Approaches*, Thousand Oaks, CA: Sage Publications, 2007.
[49] C.T. Pisarik, "Motivational orientation and burnout among undergraduate college students," College Student Journal, vol. 43, no. 4, 1238-1252, Dec. 2009.