Background

Before designing the specifications and questions for a software engineering PE exam, we need to review what licensing is, how specifications and questions are designed, and where software engineering falls in with all of this.

Terms and Definitions

I will start the background with definitions of terms used or related to this thesis.

SE
CSC
SWEBOK

History of Licensure

Before licensing laws, anybody could claim to be an engineer and practice, despite their knowledge and qualifications, or lack thereof. In the late 1800s and early 1900s, before licensing laws were in place, there was no distinction between professional engineers and untrained, unqualified individuals (1). With engineers building public infrastructure such as the Transcontinental Railroad and the Brooklyn Bridge where lives of numerous public people depend on the professional care put into the structure, the ability to make a distinction between the two became necessary.

In 1907, Wyoming passed the first law requiring registration for people who would represent themselves as engineers or surveyors to the public. Wyoming also created a state board of examiners for the profession in the same year (1)(2). Three more states passed an engineering registration law the following year, with six more states passing such a law in 1915. As these additional states started passing their own engineering laws, it became apparent that the language of these laws varied greatly from state to state. In 1920, the Iowa state board called for a meeting of the ten existing boards to
“create an organized and systemized method of procedure to be followed in interstate registration” (1).

This council coordinated reciprocal relations between the member states, meaning that licensed engineers possessing a reciprocal card issued by a licensing board would be recognized by all member states.

The reciprocal cards required that all states pass licensing laws and join this committee. By 1947, Montana became the last state to enact licensing laws, and in 1950, the entire country had some form of licensing laws (1)(2). Despite this, licensure examinations differed greatly from state to state. Some states required only an oral examination whereas others required only written exams. The exams were found to be deficient in establishing consistent standards for competence.

State boards responded by developing questions according to a rational method that would require test takers to demonstrate their ability to think like engineers (1). The boards proposed a two part exam. The first part would last two and a half days and cover fundamentals such as math, applied science, electrical and machine design, and engineering economics, law, and practice. The second part was to last half a day and cover one of five specialty engineering fields: chemical, civil, electrical, mechanical/industrial and mining/metallurgical (1). State boards eventually approved this, though with some modifications. Many boards instituted a new category of registration for engineers without experience who were interested in becoming a licensed engineer. This was the Engineer in Training exam, the first part of which was administered to college seniors and those interested in initiating the process (1). This later came to be known as the Fundamentals of Engineering (FE) exam (1)(2).

In May 1965, the first FE exam was administered in 30 states. This exam contained 30 essay questions covering 10 subjects. The following year, a national uniform Principles and Practices of Engineering (PE) exam was made available and administered (1)(2). The essay questions on the FE and PE exams have since been replaced with multiple-choice questions developed by committees, graded by computers, and psychometrically tested for fairness and relevance. The exam items are written by
volunteer licensed engineers from academia, consulting, and industry. They perform extensive surveys of professional across a range of industries which are used to determine exam specifications (1).

In 1984, all member boards started administering uniform national engineering examinations. In 1996, the afternoon portion of the FE exam started offering six discipline-specific modules to test upper-division knowledge. By October 2002, all PE exams except for Structural II are given in an all-objective scored multiple choice formats (2).

**Why License Software Engineers**

Both sides of the debate on licensing for software engineers conclude that the purpose of licensure for software engineers is to protect the public (3)(4)(5)(6)(7). Software is seeing an increased use in safety-critical applications which affects public health, safety, and welfare (8). Between 1985 and 1987, there were six known accidents involving a massive overdose from the Therac-25\(^1\) device (9). Shortly after, in 1997, the Texas Licensing Board sought licensing for software engineers working on safety-critical applications (10). At first, the Texas Board thought of software engineering as a subdiscipline of electrical engineering, much like they considered computer engineering to be. The board formed a Software Engineering Advisory Committee to help them better understand the field of software engineering, which has led to the board to instituting licensing for software engineers as it is today\(^2\) (10). Dave Parnas, a licensed professional engineer in Canada, emphasizes the importance of regulatory authorities to cooperate with computer scientists to identify the knowledge required for licensing and apply the legal mechanisms and expertise in regulating other engineering disciplines (11).

The Texas Licensing Board came to define the “practice of engineering” as shown below (12):

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\(^1\) TODO make a footnote for the Therac-25

\(^2\) TODO how is licensing in Texas done for SEs?
The “practice of engineering” means any service or creative work, the adequate performance of which requires engineering education in the application of special knowledge of the mathematical, physical, or engineering sciences to such service or work.

**Who Would Require Licensing**

An important distinction to make in the issue of licensure is defining who would require licensing. Not all software engineers would have to be licensed to practice software engineering. Table 1 shows the percentage of engineers seeking an engineering license in 1996 (13).

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Licensed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil</td>
<td>44</td>
</tr>
<tr>
<td>Mechanical</td>
<td>23</td>
</tr>
<tr>
<td>Electrical</td>
<td>9</td>
</tr>
<tr>
<td>Chemical</td>
<td>8</td>
</tr>
<tr>
<td>All Engineers</td>
<td>18</td>
</tr>
</tbody>
</table>

According to the National Society of Professional Engineers (NSPE), the differences between a registered professional engineer (PE) and an engineer is that a PE must continually demonstrate their competency and maintain and improve their skills by fulfilling continuing education requirements laid out by the state in which they are licensed (14). NSPE also makes the following notes on PEs (14):

- Only a licensed engineer may prepare, sign and seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private clients.
- PEs shoulder the responsibility for not only their work, but also for the lives affected by that work and must hold themselves to high ethical standards of practice.
Licensure for a consulting engineer or a private practitioner is not something that is merely desirable; it is a legal requirement for those who are in responsible charge of work, be they principals or employees.

Licensure for engineers in government has become increasingly significant. In many federal, state, and municipal agencies, certain governmental engineering positions, particularly those considered higher level and responsible positions, must be filled by licensed professional engineers.

Many states require that individuals teaching engineering must also be licensed. Exemptions to state laws are under attack, and in the future, those in education, as well as industry and government, may need to be licensed to practice. Also, licensure helps educators prepare students for their future in engineering.

So licensing would be required for software engineers practicing as a consulting engineer, private practitioner, certain high-level positions in government, those who sign and seal engineering work for public and private clients, and may someday be required for individuals teaching software engineering.

Current State of Software Engineer Licensing

There are four standard requirements for licensing an engineering discipline as a profession (15):

1. A Code of Ethics
2. A Body of Knowledge
3. ABET Accreditation
4. A Principles and Practices of Engineering (PE) Exam

Following is the current state of these four entities.
**Software Engineering Code of Ethics**

During their joint effort, ACM and IEEE developed and established the Software Engineering Code of Ethics (SECOE) in 1998 (16). This code of ethics lays out the foundation of how software engineers shall act in an ethical manner in their profession. The code is broken up into 8 basic principles, and each principle is subdivided into more specific codes. The code also explicitly states that some aspects of the code are subjective, leaving the ethical decision ultimately up to the practicing software engineer.

The preamble to the SECOE emphasizes the responsibility and commitment the software engineer has towards the health, safety, and welfare of the public (17). The code outlines how software engineers should act and perform in their profession. Since the SECOE does not cover knowledge areas, I do not analyze the code in this paper. However, it is still necessary to note the SECOE’s importance in the profession and its existence as mandatory for licensing to be existent for software engineers.

**Software Engineering Body of Knowledge**

ACM and IEEE, in their joint effort to increase the professionalism of software engineering, organized a task force to develop a unified body of knowledge for software engineers (18). ACM formed a committee which in 1998 determined that ACM should withdraw from these efforts and stand against any movements which would further licensure for software engineers. ACM maintains that they will continue to further software engineering as a profession (19).

IEEE successfully created a software engineering body of knowledge (SWEBOK) in 2004 which is available for purchase in PDF or book format, or for free in HTML format on their website (20). The SWEBOK establishes criteria and norms for professional practice in software engineering upon which “industrial decisions, professional certification, and educational curricula can be based” (21). The key focus that this paper looks at is what SWEBOK establishes towards professional certification, or more specifically, the principles and practices of engineering exam.
The SWEBOK is broken up into ten knowledge areas for software engineers (22). These ten knowledge areas are analyzed in detail later in this paper. The information laid out in these ten knowledge areas will also contribute to defining the material to be covered on the PE exam.

The SWEBOK is also argued about with regards to its quality. ACM and some software engineering professionals argue that the SWEBOK is not an adequate body of knowledge and also that it is a unity of knowledge as opposed to a core of knowledge (19)(23)(24). Dave Parnas claims a licensing exam should be based on a core body of knowledge (24).

**ABET Accreditation**

ACM and IEEE pursued licensing from ABET for software engineers to strengthen the profession of the discipline. ABET accreditation is also one of the necessary steps towards software engineering licensure (25). Software engineering became accredited in the early 2000’s. 15 of 23 software engineering bachelor programs were ABET accredited in 2003(4). Today, 2010, ABET reports that there are 19 software engineering programs that have obtained ABET accreditation (25).

ABET outlines general requirements for any engineering program to meet to be eligible for accreditation (26). ABET has more specific guidelines for each particular engineering profession for specific curriculum, student, and faculty requirements before accreditation is received. ABET requires that at least one student has graduated from that institution with a degree in the specified area of study before an evaluation can take place for accreditation (26). The curriculum specifications outlined by ABET can be used in the analysis and design of a software engineering PE exam specifications.

**Software Engineering Principles and Practices of Engineering Exam**

The last major milestone for licensing software engineers is the development of a principles and practices of engineering (PE) exam for that discipline. In Samuel Li’s paper on the ethics of licensing software engineers for safety-critical applications, all 8 professional software engineers Sam interviewed
agreed that software engineers should be licensed for safety-critical applications (27). In an IEEE-CS survey of software engineers in industry conducted in September 2008, 62.9% of respondents agreed that software engineers should be licensed if they practice in areas affecting public health, safety, and welfare. In addition, 61.5% supported development of software engineering licensure through NCEES Model Law (28).

A minimum of 10 states need to request for NCEES to develop a PE exam before the development of a new exam can start (4). In 2009, this number was reached, and IEEE-USA and IEEE-CS will be working together to develop such an examination (28). In IEEE-USA’s call for PE exam writers, Steven Barrett states that their committee consists of approximately 20 registered professional engineers from industry and academia who “represent the different technical specialties within electrical and computer engineering” (29). The key issue to note here is that the writers are electrical and computer engineers, not software engineers. Yet, this committee is responsible for developing the software engineering PE exam. The question this raises is how will the exam be validated against the software engineering profession when no software engineers are working on the exam?

**Bibliography**


23. Parnas, Dave. Do You Have a License to Drive That Mouse?

24. —. Developing the Specifications and Questions for a Software Engineer PE Exam. [Email] 2010.


