Professional Licensure of Biomedical Engineers

By Jay Goldberg

Part of our mission at Marquette University (and that of many other schools) is to prepare students for their personal and professional lives after graduation. The goal of our biomedical engineering capstone design course is not just to provide opportunities for students to learn about design, innovation, and the product development process but also to prepare them for careers in biomedical engineering.

Part of my role is to advise students regarding their career paths and professional development activities. As a member of the Biomedical Engineering Society and the National Society of Professional Engineers (NSPE) and as a licensed professional engineer in Illinois and Wisconsin (with 14 years of industry experience), I appreciate the value and importance of professional licensure to one's career—as well as for public safety. I encourage all our biomedical engineering students at Marquette to become licensed professional engineers.

Benefits of Licensure

The purpose of licensure is to protect the health and safety of the public. There are several benefits to licensure, including [1]

- external recognition of engineering competency for employers and the general public
- the ability to sign and seal drawings for a public authority
- career flexibility and a potentially higher salary
- the ability to provide expert testimony in a court of law
- the ability to work as a consultant and offer services to the public
- recognition as an ethical professional who has remained current in the field
- a display of pride in and commitment to one's chosen profession
- recognition by others of a significant level of engineering competence.

Becoming a professional engineer not only shows a commitment to the profession of engineering; it is an additional credential that may help differentiate a job applicant from others who are not licensed. In some fields of engineering, being a licensed professional engineer is required. In many companies, being a licensed professional engineer is considered an additional credential and is treated as a form of professional development that can command a higher salary.

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Process of Licensure

Physicians, accountants, and lawyers are required to pass an exam to prove competency in the practice of their respective professions. Physicians take medical board exams, accountants take the Uniform Certified Public Accountant Examination, and lawyers take state-specific bar exams. To prove competency in engineering, engineers take exams to become professional engineers. State boards regulate the requirements for licensure of engineers and also set standards for proof of competency in the practice of engineering.

The path to becoming a licensed professional engineer is similar in most states; it requires degreed engineers (from Accreditation Board for Engineering and Technology-accredited college programs) to pass two exams administered by the National Council of Examiners for Engineering and Surveying (NCEES). The first of these is the Fundamentals of Engineering (FE) exam, which can be taken at the end of one's senior year (or later). Students have a choice among seven FE exams, each of which focuses on a different area within engineering: Civil, Electrical and Computer, Environmental, Industrial and Systems, Mechanical, and Other Disciplines [2].

There is no specific exam for biomedical engineering, but, in my opinion, there is no need for one. Biomedical engineering students are probably best qualified to take the Other Disciplines exam, which includes questions on mathematics, probability and statistics, chemistry, instrumentation and data acquisition, ethics and professional practice, electrical and other safety topics, engineering economics, statics, dynamics, strength of materials, material science, fluid mechanics and dynamics of liquids and gases, and electricity and magnetism [3]. However, they can choose to take the exam closest to their biomedical engineering specialty if they prefer.

Because biomedical engineering is highly multidisciplinary and biomedical engineers often deal with medical applications for concepts related to mechanical (biomechanics), electrical (bioelectronics), computer (biocomputers), and materials (biomaterials) engineering, they should be (and have been) able to solve exam problems that contain elements of these disciplines and pass. Nationally, applicants who took an FE exam between January and June 2016 and identified their undergraduate degree as either biomedical (n = 40) or biological (n = 143) engineering had a pass rate of 81.3% [2].

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The second exam required for licensure is the Principles and Practice of Engineering (PE) exam. Engineers are typically required to have at least four years of engineering work experience before taking this one. Work experience in an area other than engineering—such as marketing, finance, law, or medicine—does not constitute qualifying professional experience and would not entitle one to professional licensure. The PE exam includes problems similar to those working engineers would be expected to solve. As noted before, because of the highly multidisciplinary nature of the field, biomedical engineers often deal with medical applications of multidisciplinary engineering concepts. As with the FE exam, they should be (and have been) able to solve exam problems that contain elements of other engineering disciplines and pass.

Objections to and Emerging Trends in Favor of Licensure

The two most common reasons I have heard for not encouraging biomedical engineering students to become licensed are 1) engineers can work in the medical device industry without being licensed and 2) the current licensure exams are not relevant to the field of biomedical engineering.

It is true that states grant an industrial exemption for engineers working for companies (including medical device companies). Engineers whose practices fit within at least one of the following categories are exempt from being licensed to practice engineering [4]:

- engineers working under the supervision of a licensed engineer who takes responsibility for the unlicensed engineer's work
- engineers employed by public utilities
- engineers employed by the federal government
- engineers employed by a state government
- in-house engineers employed by a manufacturing or other business firm (this is the industrial exemption).

The goal of professional licensure is to ensure the ethical and competent practice of engineering. In a study of professional licensure of engineers, the industrial exemption is challenged as not supportive of this goal [4]:

> American engineers have been surprisingly ambivalent toward licensing, if not outright rejecting of it. In a striking enigma, an overwhelming majority of engineers—somewhere around eighty percent—do not pursue licensing as a professional engineer. But even more befuddling is why the states, every one of which requires a license to practice engineering, allow the lion's share of engineering to be done by unlicensed persons, especially in light of the state's assertion that engineering licenses are necessary for the public's protection.
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> The policy underlying these exemptions, especially the industrial exemption, is perplexing. It begs the question of how an engineer's working for an industrial firm protects the public and makes licensing unnecessary. No state exempts a lawyer or physician from licensure simply because he or she is employed by the government or a corporation. How does a state justify requiring a florist to have a license, no matter where he or she works, but does not require an engineer, whose negligence can kill, to obtain a license simply because he or she works for an industrial firm?

Industrial exemptions were originally created for political reasons. Currently, florists, hairdressers, cosmetologists, and people in other regulated professions are required to be licensed to practice as professionals. As medical devices become more complex and susceptible to serious problems resulting in adverse patient outcomes, product recalls (such as those involving metal-on-metal hip implants, laparoscopic morcellators, infected endoscopes and accessories, and other devices) may become more frequent. As a result, medical consumers and state governing bodies may demand that designers of medical devices be licensed to better protect public safety and so move to repeal the industrial exemption for engineers working in the medical device industry.

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Efforts to repeal the industrial exemption have already been made. In 2014, a bill was proposed to remove the exemption for engineers in the state of Pennsylvania [5]. In 2013, a bill passed in the province of Ontario, Canada, to do the same [6]; however, a few months later, the exemption was reinstated [7]. Currently, no other province in Canada grants an industrial exemption for engineers working in industry.

An Exam Specific to Biomedical Engineering?

To answer complaints that the FE and PE exams are not relevant to the practice of biomedical engineering, there has been much discussion about the need for a biomedical engineering–specific exam. But an appropriate existing FE exam is a relevant test for biomedical engineering students. It covers exactly what its title implies—the "fundamentals of engineering." These are knowledge areas that all engineers (including biomedical engineers) should be familiar with. They are included as part of the NSPE's *Professional Engineering Body of Knowledge*, as determined with input from practicing professional engineers, engineering educators, and industry stakeholders and deemed important to professional engineering practice [8]. If biomedical engineering graduates are unable to pass an appropriate FE exam, then, in my opinion, we as educators need to question whether we are providing students with a solid engineering foundation to adequately prepare them for professional practice and careers in biomedical engineering.

As noted previously, I feel that the NCEES FE and PE exams *are* relevant to the specialties within biomedical engineering that involve electrical, computer, mechanical, and materials engineering. Although exam questions may not cover medical applications of concepts such as statics, dynamics, strength of materials, stress analysis, fluid mechanics, thermodynamics, or circuit analysis, they do address these concepts in other nonmedical applications. Biomedical engineers should be able to recognize situations

where these basic concepts apply to nonmedical applications and correctly solve the exam problems. This is borne out by the fact that, while only a small number of biomedical engineering graduates take the PE exam, many of those who do, pass successfully.

Looking Ahead

As we prepare our biomedical engineering students for professional practice, we should encourage them to become licensed. Licensure provides many benefits to engineers, employers, and the general public and can only enhance one's career. If we are providing our students with a solid foundation in engineering fundamentals, then they should able to pass existing FE and PE exams. As medical devices become more complex, the potential for more product recalls increases. If patient outcomes are adversely affected by product failures, then medical consumers and state regulators could demand a repeal of the industrial exemption to better protect the public. If licensed, our students will be prepared for these potential changes.

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RETROSPECTROSCOPE *(continued from page 41)*

one's heart, no doubt catching the vulnerable period. Marconi was right after all in saying, when he argued against Westinghouse's stand in its struggle to impose one type of current over the other (and forgetting transmission efficiency), that ac is more dangerous; he even ran experiments on dogs, for that matter. But that is another well-known story.

Postscript: Because I was reborn at age 24, that means I am 24 years younger now. Despite the pain I went through, the deal turned out to be advantageous!

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