2018 ASEE Annual Conference & Exposition
June 24–27, 2018, Salt Palace Convention Center, Salt Lake City, UT

Paper ID #21137

Specialization Within the Civil Engineering Profession: Issues, Analysis, and Recommendations

Dr. Stephen J. Ressler P.E., United States Military Academy

Stephen Ressler, P.E. Ph.D. is Professor Emeritus from the U.S. Military Academy (USMA) at West Point. He earned a B.S. degree from USMA in 1979, a Master of Science in Civil Engineering from Lehigh University in 1989, and a Ph.D. from Lehigh in 1991. As an active duty Army officer, he served for 34 years in a variety of military engineering assignments around the world. He served as a member of the USMA faculty for 21 years, including six years as Professor and Head of the Department of Civil and Mechanical Engineering. He retired as a Brigadier General in 2013. He is a registered Professional Engineer in Virginia, a Distinguished Member of ASCE, and a Fellow of ASEE.

Dr. Thomas A. Lenox, American Society of Civil Engineers (Retired)

Thomas A. Lenox, Ph.D., Dist.M.ASCE, F.ASEE is Executive Vice President (Emeritus) of the American Society of Civil Engineers (ASCE). He holds a Bachelor of Science degree from the United States Military Academy (USMA), Master of Science degree in Theoretical & Applied Mechanics from Cornell University, Master of Business Administration degree in Finance from Long Island University, and a Ph.D. degree in Civil Engineering from Lehigh University. Dr. Lenox served for over 28 years as a commissioned officer in the U.S Army Field Artillery in a variety of leadership positions in the U.S., Europe, and East Asia. He retired at the rank of Colonel. During his military career, Dr. Lenox spent 15 years on the engineering faculty of USMA – including five years as the Director of the Civil Engineering Division. Upon his retirement from the U.S. Army in 1998, he joined the staff of the American Society of Civil Engineers (ASCE). In his position as educational staff leader of ASCE, he managed several new educational initiatives – collectively labeled as Project ExCEEd (Excellence in Civil Engineering Education). As ASCE's Executive Vice President, Dr. Lenox led several educational and professional career-development projects for the civil engineering profession – with the overall objective of properly preparing individuals for their futures as civil engineers. An example is his staff leadership of ASCE's initiative to "Raise the Bar" for entry into professional engineering practice. Dr. Lenox's awards include ASCE's ExCEEd Leadership Award, ASEE's George K. Wadlin Award, ASCE's William H. Wisely American Civil Engineer Award, and the CE News' "2010 Power List – 15 People Advancing the Civil Engineering Profession." He is a Distinguished Member of ASCE and a Fellow of ASEE. In January 2014, Dr. Lenox retired from his staff position with ASCE. He continues to serve the engineering profession as an active member of ABET's Board of Delegates, Global Council, and Governance Committee; several of ASCE's education and accreditation committees; and ASEE's Civil Engineering Division.

Specialization within the Civil Engineering Profession: Issues, Analysis, and Recommendations

Purpose and Scope

The purpose of this paper is to address a range of issues associated with the definition, development, educational paradigm, and credentialing systems associated with technical specialty areas in the civil engineering profession. After describing these issues, we analyze them, first through comparison with the current system of specialization in the medical profession, then in the broader context of a theoretical model from the Sociology of Professions. Based on this analysis, we offer recommendations for strengthening the profession through more purposeful management of specialization within civil engineering.

Specialization in Civil Engineering

According to the American Society of Civil Engineers (ASCE) Policy Statement 465, ASCE "supports the attainment of the Civil Engineering Body of Knowledge (CEBOK) for entry into the practice of civil engineering at the professional level…through appropriate engineering education and experience, and validation by passing the licensure examinations [1]." This policy further states that the BOK includes five principal components: (1) fundamentals of math, science, and engineering science, (2) technical breadth, (3) breadth in the humanities and social sciences, (4) professional practice breadth, and (5) technical specialization. Thus, as a matter of official ASCE policy, technical specialization is integral to the preparation of civil engineers for professional practice. This policy is appropriately reinforced by the CEBOK itself, which defines Outcome 15 Technical Specialization as one of the 24 outcomes comprising the body of knowledge [2].

Issues with Technical Specialty Areas

Despite the evident importance of technical specialization in civil engineering professional practice, the current process by which civil engineers are prepared for professional practice in their specialty areas is hindered by three major issues.

Issue #1: Lack of an authoritative definition of the civil engineering specialty areas

What are the civil engineering specialty areas? Neither Policy Statement 465 nor any other formal ASCE policy identifies them explicitly.

The CEBOK does provide guidance on the identification of specialty areas; however, this guidance is neither definitive (because the guidance is somewhat ambiguous) nor authoritative (because the CEBOK is not itself an ASCE policy statement). With no explicit justification, the CEBOK specifies that "advanced technical specialization includes all traditionally defined areas of civil engineering practice," while also encouraging the inclusion of emerging fields, such as ecological engineering and nanotechnology [2]. The CEBOK identifies the "traditionally defined areas of civil engineering practice" as construction engineering, environmental engineering, geotechnical engineering, structural engineering, surveying, transportation engineering, and water resources engineering; however, this definition is actually stated in the context of *technical* *breadth* (Outcome 14), rather than technical specialization (Outcome 15). We see no clear justification for simply *assuming* that the seven traditional civil engineering sub-disciplines, which constitute the breadth component of the traditional baccalaureate civil engineering curriculum, are also appropriate areas of advanced specialization. For example, while basic-level surveying is an appropriate component of a civil engineer's technical breadth, specialists in surveying are typically registered professional land surveyors, not professional engineers.

The ambiguity in the definition of civil engineering specialty areas is exacerbated by the organization of ASCE's technical institutes [3]. Given that the institutes exist to "provide members with access to technical, educational, and professional resources in specialty areas," one might expect a one-to-one alignment between the institutes and the traditional civil engineering specialty areas. However, such is not the case, as indicated by Figure 1. Two institutes (AEI and EMI) do not align with any of the traditional civil engineering areas. One institute (EWRI) aligns with two different civil engineering areas, while both EWRI and COPRI align with the single area of water resources engineering. Two other institutes (T&DI and UESI) align only partially with civil engineering areas, leaving Development and Utility Engineering uncovered.

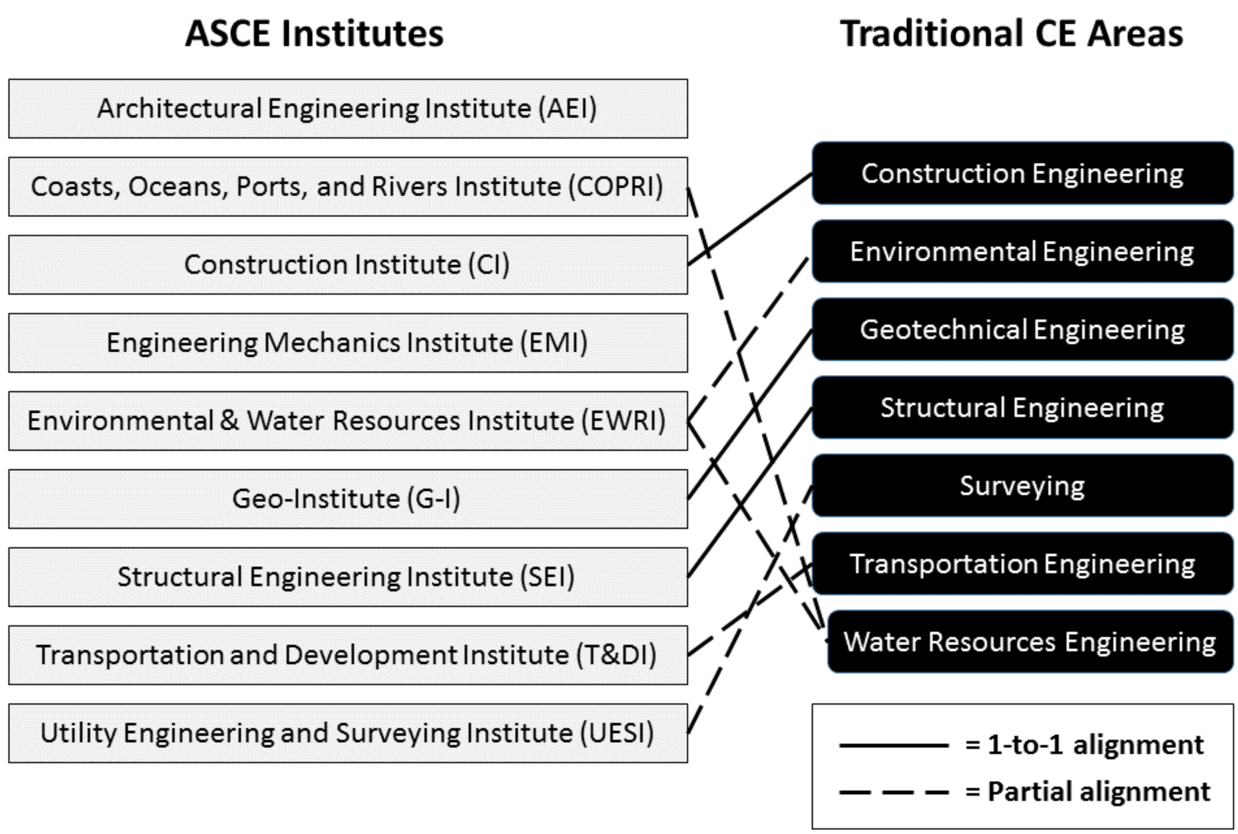

Figure 1. Alignment between ASCE institutes and traditional civil engineering areas

Issue #2: Lack of a fully-realized educational paradigm for the development of civil engineers who are prepared for professional practice in a given specialty area

The educational paradigm advocated by ASCE Policy Statement 465 consists of (1) a baccalaureate degree in civil engineering and (2) a master's degree in engineering or no less than 30 graduate or upper level undergraduate technical and/or professional practice credits as academic prerequisites for professional licensure. The CEBOK further clarifies this model, specifying that the baccalaureate degree should address all 24 outcomes, each at an appropriate level of achievement, while the master’s degree (or equivalent) should focus primarily on technical specialization [2]. This model is highly consistent with published strategic visions for educating future engineering professionals [4], [5], [6].

ASCE’s proposed educational paradigm has been *partially* realized, in two respects. First, CEBOK-compliant baccalaureate-level Civil Engineering Program Criteria have been developed and implemented [7]. The most recent version of these criteria (which supplement the ABET Criteria for Accrediting Engineering Programs) was approved by the ABET Board of Delegates in October 2015 and implemented for accreditation visits starting in the fall of 2016 [8].

Second, many graduate programs focused in civil engineering specialty areas are already offered. In a survey of 232 master’s degree programs at 121 of the 186 institutions offering CE-related graduate programs, the most common CE-related specialty master’s programs were as follows [9]:

- Environmental Engineering (167 programs)
- Structural Engineering (154 programs)
- Water Resources (139 programs)
- Geotechnical Engineering (137 programs)
- Transportation Engineering (120 programs)
- Hydraulics/Fluid Mechanics (94 programs)
- Hydrology (93 programs)
- Construction (74 programs)

Unfortunately, the master’s-level component of ASCE’s proposed educational paradigm has not yet been fully realized. Formal establishment of the master’s degree (or equivalent) as an academic prerequisite for licensure can only be achieved with changes to state licensure laws—an outcome that ASCE has not yet been successful in effecting. Yet even in the absence of a formal legislative solution to this challenge, certain segments of the civil engineering profession are moving voluntarily toward ASCE’s proposed educational paradigm as a *de facto* standard. In structural engineering, for example, there is a growing consensus that a master’s degree is required for professional practice in all but the smallest firms [10].

This *ad hoc* progress notwithstanding, ASCE’s proposed educational paradigm is simultaneously being undercut by two counterproductive trends. First, SEI’s recently published “Vision for the Future of Structural Engineering and Structural Engineers” proposes a fundamentally new educational paradigm which would effectively decouple master’s-level structural engineering education from its traditional prerequisite—the baccalaureate-level civil engineering degree [10].

Second, an increasing number of engineering programs are being accredited in narrow specialty areas at the baccalaureate level. This trend has been enabled by ABET policies that allow (and indirectly encourage) the accreditation of programs with non-standard program names (e.g., Water Supply and Wastewater Engineering, Ecological Engineering, Facilities Engineering), while specifying no requirement for compliance with any Program Criteria [11]. For example, the baccalaureate-level Structural Engineering degree program at the University of California San Diego has been accredited by the Engineering Accreditation Commission of ABET, with no requirement for compliance with the EAC Civil Engineering Program Criteria [12]. It is also worth noting that EAC Program Criteria have been published for both Environmental Engineering and Construction Engineering [7], thus allowing baccalaureate-level accreditation in these disciplines—both of which are traditionally regarded as civil engineering specialty areas. To the extent that baccalaureate-level accreditation of programs in specialty sub-disciplines is allowed to continue, the educational paradigm for the preparation of professional civil engineers will remain ambiguous and inconsistent.

Issue #3: Lack of a coherent system for credentialing practitioners in the civil engineering specialty areas

There are two available mechanisms for credentialing engineering practitioners in technical specialty areas—*licensure* and *board certification*.

In the U.S., professional licensing is regulated by the states, rather than the federal government. Thus, each of the 55 licensing jurisdictions (which include states and territories) has its own unique engineering licensing statute, which can only be changed by the state legislature [13]. As a result of this decentralization, licensure systems vary widely across the U.S. Nonetheless, these various systems can all be placed into the following broad categories:

(1) Generic P.E. license – Engineers are licensed only as Professional Engineers (P.E.), regardless of their engineering discipline; e.g., civil, mechanical, electrical, etc. Most U.S. jurisdictions use generic licensing.

(2) Discipline-specific P.E. license - Engineers are licensed as P.E.s; however, the state's licensure statute restricts them to practice only in the specific discipline (e.g., civil, mechanical, electrical) in which they are licensed. Eleven U.S. jurisdictions currently use discipline-specific licensing, and several others are currently considering it [14]. In some jurisdictions (e.g., Massachusetts), the list of licensed disciplines includes, not only civil engineering, but environmental and structural engineering as well [15]. The National Council of Examiners for Engineering and Surveying (NCEES) supports this practice by providing Principles and Practice of Engineering (PE) exams in these specialty areas.

(3) P.E. license plus specialty area license – Engineers are licensed first as P.E.s, then subsequently in an advanced specialty area. ASCE supports this licensing model through its Policy Statement 524 [16]. Currently, the only CE specialty licenses available in the U.S. are in structural engineering (S.E.) and geotechnical engineering (G.E.):

- P.E. license plus S.E. license – In five jurisdictions (Alaska, California, Oregon, Utah, and Washington), a licensed P.E. can subsequently seek licensure as a Structural Engineer (S.E.) after passing a special 16-hour examination. In these states, the S.E. license is required to design all structures in specified categories [17]. In its Policy Statement 101, SEI encourages professional engineers practicing structural engineering to pursue the S.E. license as a post-P.E. credential [18]. The broader structural engineering community is also currently engaged in a coordinated initiative to promote the S.E. license as a post-P.E. credential [19].

- P.E. license plus G.E. license – The state of California grants the authority to use the title Geotechnical Engineer (G.E.) to licensed civil engineers who meet additional experience requirements and pass a special geotechnical engineering exam [20].

(4) Stand-alone S.E. license – In three jurisdictions (Illinois, Hawaii, and Nevada), an engineer can be licensed as a S.E. without having first been licensed as a P.E. [17]

Of these four systems, (3) and (4) unequivocally involve the credentialing of a civil engineering specialty area and thus are directly relevant to this paper. Alternative (2) is also relevant, in that it accommodates discipline-specific P.E. licensing in the structural and environmental engineering areas, which have traditionally been regarded as civil engineering specialty areas.

The alternative to licensure as a means of credentialing engineers in advanced specialty areas is *board certification*. ASCE offers board certification through its institutes in six specialty areas:

- Coastal Engineering
- Geotechnical Engineering
- Navigation Engineering
- Ocean Engineering
- Ports Engineering
- Water Resources Engineering

The minimum requirements for these board certifications are a P.E. license (or equivalent), a master's degree, and 8 years of progressive post-licensure engineering experience [21]. The Structural Engineering Certification Board—a partnership of the National Council of Structural Engineering Associations (NCSEA), the Structural Engineering Licensure Coalition (SELC), and SEI—offers board certification in structural engineering, albeit with substantially different standards [22]. And the American Academy of Environmental Engineers and Scientists (AAEES) offers board certification in environmental engineering [23].

In summary, various means of credentialing professional engineers in advanced civil engineering specialty areas exist; however, they are characterized by severe limitations and inconsistencies:

- S.E. licensure is available in only eight jurisdictions.

- The prerequisites for S.E. licensure are inconsistent.
- G.E. licensure is available in only one jurisdiction.
- Board certification is offered by three different professional organizations, using different standards.
- Board certification is not available in all civil engineering specialty areas.

Specialization in the Medical Profession

In assessing the significance of these issues, it is useful to compare the ill-defined system of specialization in civil engineering with the highly structured system of specialization in the medical profession.[*]

All medical specialty areas are clearly and authoritatively defined by the American Board of Medical Specialties (ABMS). Established in 1933, the ABMS is a non-profit organization comprised of 24 certifying boards that develop and implement professional standards for the certification of physicians in their declared medical specialties [24]. These boards certify physicians in 39 different medical specialties and 86 medical subspecialties. Examples of medical specialties include Anesthesiology, Dermatology, Internal Medicine, Radiology, and Urology. Subspecialties of Internal Medicine include Cardiology, Endocrinology, Hematology, Infectious Disease, and Rheumatology [25].

To be eligible for certification as a Medical Specialist, an individual must [26]:

(1) complete baccalaureate-level premedical education at a college or university (typically 4 years);
(2) earn a medical degree from an accredited medical school (typically 4 years);
(3) obtain an unrestricted medical license to practice medicine from a state (after one year of residency experience);
(4) complete a full-time experience in an accredited residency training program in a medical specialty (typically 2 additional years); and
(5) if pursuing a career in a medical subspecialty, complete a full-time experience in an accredited residency program in that medical subspecialty (typically 3 years).

After completing (1) through (4) above, a candidate for specialty certification must pass an exam created and administered by the certification board for his or her specialty. After passing this exam, the candidate is considered certified as a specialist and a diplomate of the specialty board.

A candidate pursuing a career in a subspecialty must first attain certification in the associated medical specialty. Then, after completing (5) above, he or she must successfully complete an assessment of knowledge and clinical judgment in the subspecialty discipline.

As outlined above, the time required for preparation to practice medicine as a physician is typically five years beyond the baccalaureate degree, while the preparation time for a Medical Specialist is typically seven to ten years beyond the baccalaureate degree. Despite the

---

[*] For the purpose of this comparison, the term "medical profession" refers only to the body of individuals who work as doctors of medicine. It does not refer to other health care professionals, such as Registered Nurses, Nurse Practitioners, and Physician's Assistants.

substantial additional demands associated with certification, approximately 80% of all licensed physicians in the United States are Board Certified Medical Specialists [27].

This high percentage reflects the medical profession's collective commitment to providing the public with a high level of specialized expertise; however, it also reflects the system's strong internal incentives for board certification. Most hospitals require board certification to practice in a medical specialty area, and insurance fee reimbursement rates are typically tied to board certification. Furthermore, many hospitals have independently made the decision to require board certification for staff privileges [28]. Thus, from the physician's perspective, certification serves as both a carrot and a stick.

In summary—and in sharp contrast with civil engineering:

- The specialty areas of the medical profession are clearly and authoritatively defined.
- The educational and experiential paradigm for the development of medical specialists is rigorous, universally acknowledged, and consistently applied.
- There is a coherent system for credentialing physicians in the medical specialty and subspecialty areas.
- The system provides strong professional and economic incentives for board certification.

Specialization in the System of Professions

Having identified three major issues associated with specialization in civil engineering, and having illustrated their severity through a comparison with specialization in the medical profession, we now consider specialization within the context of a broader theoretical framework—the *system of professions*, as defined by sociologist Andrew Abbott [29].

Abbott's conceptual model of professionalism is unique, in that he applies systems analysis concepts to characterize the professions as interdependent elements of a complex, dynamic system. At the heart of this system is the concept of *jurisdiction*—the link between a profession and its work. Each profession claims a jurisdiction based on its associated body of expert knowledge. Control of a jurisdiction generally entails the right to perform work as the profession sees fit, to exclude others from doing the same work, and to define publicly the tasks being performed.

Within Abbott's theoretical system of professions, a disturbance is created when one occupation attempts to claim another's jurisdiction, or when external forces (such as technological change) create new jurisdictions or destroy existing ones. This disturbance then propagates through the system as a succession of jurisdictional contests between occupations. Eventually the disturbance is absorbed, either by professionalization of a non-professional occupation, by de-professionalization of a professional group, or by internal changes within a profession. Ultimately the outcomes of these jurisdictional disputes determine whether professions prosper, combine, subdivide, stratify, or fail. And because professional tasks are constantly changing, new jurisdictional disputes are always arising. Consequently, there can be no long-term equilibrium in the system.

According to Abbott, the history of economic development has been characterized by ever-increasing specialization. There are two fundamental types of specialization:

- *Mechanical specialization* is the specialization of the assembly line. It involves the breakdown of a complex operation into a series of relatively simple tasks, any one of which can be accomplished primarily by using everyday knowledge and skills, perhaps with some modest on-the-job training.

- *Discretionary specialization* requires the application of discretionary judgment to accomplish complex tasks. The exercise of discretionary judgment is based on the employment of a body of knowledge gained primarily through specialized training.

Similarly, Abbott identifies two types of knowledge:

- *Practical knowledge* is acquired primarily through experience and is focused on performing well-defined tasks with minimal regard for abstract theories or concepts.

- *Formal knowledge* is based primarily on abstract theories and concepts—some of which are acquired through our everyday experiences and schooling, but most of which are learned through specialized training, typically in a specific discipline of study.

Combining these two classifications, Abbott defines three types of occupational groups whose work is characterized by discretionary specialization:

- Occupations that exhibit discretionary specialization based primarily on practical knowledge are *skilled craft occupations* (e.g., the construction trades).

- Occupations that exhibit discretionary specialization based primarily on formal knowledge are *professions*.

- Occupations that exhibit discretionary specialization based on a mix of formal and practical knowledge are *paraprofessional occupations* (e.g. technologists and technicians).

We can conclude, then, that the essence of professionalism is discretionary specialization with respect to a formal body of knowledge that incorporates abstract theories and concepts. Furthermore, according to Abbott, as a profession's body of knowledge expands and diversifies—either through the creation of new knowledge or the expansion of the profession's jurisdiction—there is a corresponding tendency toward increased *specialization within the profession*. And under some circumstances, this internal specialization can lead to subdivision of the profession into two or more independent occupational groups.

Consistent with Abbott's theoretical model, the history of civil engineering as a profession has been characterized by constantly increasing internal specialization and occasional subdivision.

- Civil engineering emerged as a distinct professional group with the founding of the British Society of Civil Engineers in 1771, primarily to differentiate civilian (i.e., non-military) engineers from military engineers [30].

- Seventy-six years later, in 1847, British mechanical engineers split from civil engineering and founded the Institution of Mechanical Engineers, primarily to accommodate the growing need for mechanical specialization in the railroad and manufacturing industries [31].

- In 1871, mining engineers split away from civil engineering to form the American Institute of Mining Engineers [29], [32].

- In 1955, ASCE joined with four other professional organizations (the American Public Health Association, American Society for Engineering Education, American Water Works Association, and Water Pollution Control Federation) to form the American Engineering Intersociety Board (AEIB), for the purpose of advancing the environmental engineering specialty area *under the umbrella of the five parent organizations*. By 1966, however, the AEIB had evolved into an independent professional society—the American Academy of Environmental Engineers [33].

- Today, the civil engineering discipline continues to experience specialization within the profession, as evidenced by the establishment of the ASCE technical institutes, as well as specialty-oriented industry organizations like the National Council of Structural Engineering Associations (NCSEA) [34].

Abbott describes this dynamic process as an entirely normal aspect of the system of professions. Specialization occurs within professions, he says, when the knowledge and skills required for a given task area expand beyond the ability of any individual practitioner to acquire. Thus, after specialization has occurred, the individual practitioner will be able to achieve a higher level of expertise in a narrower domain of knowledge. Across the profession, the aggregate effect is a higher level of expert knowledge and, therefore, enhanced capacity to diagnose and solve problems in the professional jurisdiction. The ultimate result is a stronger profession.

From the professional society's perspective, the obvious downside of specialization is the potential for specialist groups to break away from the parent profession and become independent. Abbott emphasizes, however, that specialization does not inevitably lead to subdivision, particularly for mature professions. Indeed, specialists usually do not split away from their parent profession, because the parent profession provides them with the full protections of professionalism—most importantly, an established professional jurisdiction and a sheltered position in the labor market. Rather than breaking away, specialist groups usually prefer to develop special education and certification structures within the parent professional organization. Parent professions that are willing to accommodate this preference are less likely to experience subdivision.

There are two circumstances in which formal subdivision of a profession is more likely to occur:

- A specialist group is performing essentially the same work as one or more external groups (as was the case with environmental engineers splitting from ASCE to join with the American Public Health Association, American Water Works Association, and Water Pollution Control Federation).

- A specialist group is performing tasks that are not safely within the "heartland" of the parent profession's jurisdiction (as was the case with mining engineering splitting from civil engineering).

Conclusions and Recommendation

The analysis above yields the following important conclusions:

(1) Specialization is integral to professionalism.

(2) Increasing internal specialization is a normal phenomenon in the long-term development of a profession. This process is indicative of a healthy, growing profession, in the sense that increasing specialization typically reflects an increase in the scope of the professional body of knowledge.

(3) Specialization occurs when the knowledge and skills required for a given task area exceed the ability of an individual practitioner to acquire. Thus, the beneficial effect of specialization is that individual practitioners can achieve higher levels of expertise in relatively narrower domains of knowledge.

(4) At the most fundamental level, the strength of a profession derives from its ability to diagnose and solve problems effectively within its professional jurisdiction. In this sense, internal specialization can significantly strengthen a profession, because it promotes higher levels of expert knowledge.

(5) A profession can accommodate the emergence of new specialty areas—and thereby prevent them from breaking away to form independent professional groups—by formally recognizing these specialists and supporting the creation of specialized education and certification structures.

(6) A specialist group is more likely to split away from its parent profession if it is performing the same type of work as an external group, or if its work is outside the "heartland" of the professional jurisdiction.

(7) The medical profession is greatly strengthened by its well-structured system of specialization. This system is characterized by authoritative definition of specialties, a well-established educational paradigm, a coherent credentialing system, and strong incentives for achieving specialty certification. The high rate of board certification

reflects a high level of expert knowledge across the profession—and thus a strong capacity to diagnose and solve problems in the professional jurisdiction.

(8) In sharp contrast with the medical profession, the civil engineering profession has made only cursory efforts to manage internal specialization. The civil engineering specialty areas have never been authoritatively defined, and the seven "traditional civil engineering discipline areas" are not well aligned with ASCE's technical institutes. Through Policy Statement 465, ASCE has proposed a coherent educational model that appropriately incorporates specialization; however, the master's-level component of this model is unlikely to be implemented in the near term, due to ASCE's inability to influence state licensure laws. In the meantime, the model is being undercut by the ongoing trend toward accreditation of baccalaureate degree programs in narrow specialty sub-disciplines. Finally, the current credentialing system for civil engineering specialists is both inconsistent and incomplete.

(9) It is quite likely that the structural engineering community's ongoing efforts to pursue education and credentialing initiatives independent from ASCE can be attributed, at least in part, to ASCE's inattention to the management of specialization within civil engineering.

(10) The aggregate result of poorly managed specialization within civil engineering is a profession that is neither as strong as it should be nor is serving the public as well as it could.

Based on these conclusions, we recommend:

(1) That ASCE establish a task committee to identify and formally define the civil engineering specialty areas. This process should be guided by the principles articulated in Abbott's model: (1) that each specialty should be a current technical area of professional practice, with its scope of required knowledge attainable by an individual practitioner and (2) that conditions conducive to subdivision of the profession are avoided.

(2) That the civil engineering specialty areas be formalized in an ASCE policy statement.

(3) That the ASCE institutes be aligned as closely as possible with the civil engineering specialty areas.

(4) That ASCE support the establishment of credentialing programs for all civil engineering specialties.

(5) That each ASCE-supported credentialing program be structured as either (a) a P.E. license plus specialty area license or (b) a P.E. license plus board certification.

(6) That ASCE encourage all civil engineering organizations and companies to establish policies offering appropriate professional and economic incentives for those credentialed in a civil engineering specialty area.

(7) That ASCE continue its efforts to change the existing ABET policies that allow baccalaureate-level accreditation of programs in narrow specialty areas.

(8) That ASCE pursue master's-level ABET EAC accreditation—but not baccalaureate-level accreditation—of programs in the CE specialty areas.

Planning and implementing these actions would entail substantial challenges and would require many years to implement. Yet the long-term benefits to the profession and the public would be greater still.

References

[1] ASCE, "Policy Statement 465 – Academic Prerequisites for Licensure and Professional Practice," accessed at http://www.asce.org/issues-and-advocacy/public-policy/policy-statement-465---academic-prerequisites-for-licensure-and-professional-practice/, January 14, 2018.

[2] Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice, *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future (Second Edition).* Reston, VA: ASCE, 2008.

[3] ASCE, "Institutes," accessed at http://www.asce.org/institutes/, January 14, 2018.

[4] National Academy of Engineering, *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, D.C.: National Academies Press, 2004.

[5] National Academy of Engineering, *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. Washington, D.C.: National Academies Press, 2005.

[6] A.G. Ulsoy, Ed., "Report of the '5XME' Workshop: Transforming Mechanical Engineering Education and Research in the USA." National Science Foundation, Arlington, VA, May 10-11, 2007.

[7] ABET, "Criteria for Accrediting Engineering Programs, 2018-19," accessed at http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2018-2019/, January 15, 2018.

[8] A. C. Estes, T. A. Lenox, K. J. Fridley, and R. O. Anderson, "Accreditation Insights and the Next Body of Knowledge," *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference*, June 2016.

[9] J. S. Russell, J. M. Rogers, T. A. Lenox, and D. K. Coward, "Civil Engineering Master's Programs: A Comprehensive Review of Types and Requirements," *Proceedings of the 2011 Annual Conference of ASEE*, June 2011.

[10] Structural Engineering Institute, American Society of Civil Engineers, "A Vision for the Future of Structural Engineering and Structural Engineers: A Case for Change," Board of Governors Task Committee Paper, October 16, 2013, accessed at http://www.asce.org/uploadedFiles/visionforthefuture.pdf , February 8, 2017.

[11] S. J. Ressler and T. A. Lenox, "Accreditation Issues of Strategic Importance to the Civil Engineering Profession," *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference*, June 2014.

[12] UC San Diego, Jacobs School of Engineering, "Structural Engineering," accessed at https://structures.ucsd.edu/academics/undergraduate-program, February 9, 2017.

[13] C. N. Musselman, J. D. Nelson, and M. L. Phillips, "Engineering Licensure Laws and Rules, Today and Tomorrow," *Proceedings of the 2011 Annual Conference of ASEE*, June 2011.

[14] C. N. Musselman. et al., "Licensure Issues of Strategic Importance to the Civil Engineering Profession - and ASCE," *Proceedings of the 2016 Annual Conference of ASEE*, June 2016.

[15] Commonwealth of Massachusetts, "Professional Engineers and Land Surveyors Licensing," https://www.mass.gov/professional-engineers-and-land-surveyors-licensing, accessed January 15, 2018.

[16] ASCE, "Policy Statement 524 – "Licensure And Advanced Credentialing Within The Civil Engineering Profession," accessed at http://www.asce.org/issues-and-advocacy/public-policy/policy-statement-524---licensure-and-advanced-credentialing-within-the-civil-engineering-profession/, February 1, 2018.

[17] S. J. Ressler and T. A. Lenox, "Structural Engineering Education and Accreditation: Perspectives, Developmental Paradigms, and Recommendations," *Proceedings of the 2017 Annual Conference of ASEE*, June 2017.

[18] SEI, ASCE, "Policy Statement 101 – "Structural Engineering License," accessed at http://www.asce.org/uploadedFiles/Technical_Areas/Structural_Engineering/sei-policy-101.pdf, February 1, 2018.

[19] Structural Engineering Licensure Coalition (SEI, NCSEA, SECB, CASE), accessed at http://www.selicensure.org/position-statement, February 1, 2018.

[20] California Board of Professional Engineers, Land Surveyors, and Geologists, "Information and Instructions: California Geotechnical Engineer Application," accessed at http://www.bpelsg.ca.gov/applicants/geappinst.shtml, January 15, 2018.

[21] ASCE, "Board Certifications," accessed at http://www.asce.org/professional_certifications/, January 15, 2018.

[22] Structural Engineering Certification Board, "Certification," http://www.secb.org/certification/faqs/, accessed March 18, 2018.

[23] American Academy of Environmental Engineers and Scientists, "Board Certification Programs," http://www.aaees.org/becomeboardcertified/, accessed January 15, 2018.

[24] American Board of Medical Specialties (ABMS), "Fact Sheet: American Board of Medical Specialties (ABMS) and the ABMS Maintenance of Certification Program," accessed at http://www.abms.org/media/1209/abms_fact_sheet.pdf, January 16, 2018.

[25] ABMS, *ABMS Board Certification Report, 2016-2017*. Chicago: ABMS, 2017.

[26] ABMS, *ABMS Guide to Medical Specialties*. Chicago: ABMS, 2017.

[27] A. Young and K. Arnhart, "A Census of Actively Licensed Physicians in the United States, 2016." *Journal of Medical Regulation*, vol. 103, no. 2, 2017, pp.7-21.

[28] ABMS, "A Trusted Credential," accessed at http://www.abms.org/board-certification/a-trusted-credential/, January 16, 2018.

[29] A. Abbott, *The System of Professions: An Essay on the Division of Expert Labor*. Chicago: University of Chicago Press, 1988.

[30] “Smeatonian Society of Civil Engineers,” accessed at https://en.wikipedia.org/wiki/Smeatonian_Society_of_Civil_Engineers, January 15, 2018.

[31] “Institution of Mechanical Engineers,” accessed at https://en.wikipedia.org/wiki/Institution_of_Mechanical_Engineers, January 15, 2018.

[32] American Institute of Mining, Metallurgical, and Petroleum Engineers, “About Us,” accessed at http://www.aimehq.org/about-us, January 15, 2018.

[33] American Academy of Environmental Engineers and Scientists, “The History of AAEES,” accessed at http://www.aaees.org/aboutaaees/history.php, January 15, 2018.

[34] “National Council of Structural Engineering Associations,” http://www.ncsea.com/, January 15, 2018.