Who Should Teach the Civil Engineering
“Body of Knowledge?”

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Abstract

The American Society of Civil Engineers (ASCE) has raised the bar in defining professional status for civil engineers in its Policy Statement 465. In support of that statement ASCE has developed a document that defines the “Body of Knowledge” that should be addressed in civil engineering programs that lead to a professional degree. This paper describes the current efforts by ASCE’s Committee on Faculty Development to define who should teach the body of knowledge. Discussion focuses on faculty credentials, methods of content delivery, and venue of programs, e.g., in-residence versus distance education programs.

Introduction

Since the mid 1990s ASCE leadership has supported the notion that formal education of civil engineers beyond the baccalaureate degree was required as a prerequisite for professional registration. This concept was initially proposed in 1998 with the moniker “Master’s as the First Professional Degree.” This notion of increased formal education met with some negative reaction from the rank and file membership of ASCE.\(^1\) and as a result the ASCE Board of Direction formed the Task Committee for the First Professional Degree to define the need for additional formal education. In October of 2001 that committee produced a report titled “Engineering the Future of Civil Engineering.” This report highlighted the significant changes and complexity confronting the profession and documented the potential risks to public safety health and welfare if the profession did not respond to these changes and complexities. Most importantly, the report concluded that the current four-year bachelor’s degree was becoming inadequate as formal preparation for the professional practice of civil engineering. In November 2001 the ASCE Board of Direction adopted Policy 465 which, in part “supports the concept of the master’s degree or equivalent as a prerequisite for licensure and the practice of civil engineering at the professional level.”\(^2\) In addition to adopting Policy 465 ASCE created the Task Committee on Academic Preparation for Professional Practice (TCAP\(^3\)) and charged it to “…develop, organize and execute a detailed plan for full realization of the ASCE Policy Statement 465.” This committee, which was later made a board level standing committee (CAP\(^3\)), formulated the Civil Engineering Body of Knowledge (BOK) which was formally released in January of 2004. As a result of the CAP\(^3\) report on the BOK, ASCE’s Policy Statement 465 was revised in October 2004 to reflect the work of the committee. It now states in part that “ASCE…supports the attainment of a Body of Knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure.”
The Body of Knowledge report\[^2\] presented the recommendations of the CAP\[^3\] and the process used to arrive at those recommendations. Specifically, the report described what should be taught, how it should be taught and who should teach and learn it. The committee used an outcomes based approach to determine what should be taught. They established 15 outcomes which prescribe the greater educational depth and breadth required of the civil engineer of the future. Embedded in these 15 outcome are the 11 “a thru k” outcomes specified by ABET\[^3\]. As a result of employer surveys and a review of the literature the CAP\[^3\] recommended the following four additions to the ABET outcomes: \[^2\]

12. an ability to apply knowledge in a **specialized area related to civil engineering**.
*Commentary:* For a professional civil engineer, specialized technical coursework (or the equivalent) is necessary. Examples of specialized technical areas include environmental engineering, structural engineering, construction engineering and management, public works management, transportation engineering and water resources management. Civil engineering specializations in non-traditional, boundary, or emerging fields such as ecological engineering and nano-technology are encouraged.

13. an understanding of the elements of **project management, construction, and asset management**.
*Commentary:* Efforts of the professional civil engineer often lead, in the context of projects, to construction of structures, facilities and systems that, in turn, must be operated and maintained. Project management essentials include project manager responsibilities, defining and meeting client requirements, risk assessment and management, stakeholder identification and involvement, contract negotiation, project work plans, scope and deliverables, budget and schedule preparation and monitoring, interaction among engineering and other disciplines, quality assurance and quality control, and dispute resolution processes. Important construction elements are owner-engineer contractor relationships; project delivery systems (e.g., design-bid-build, design-build); estimating construction costs; bidding by contractors; labor and labor management issues; and construction processes, methods, systems, equipment, planning, scheduling, safety, cost analysis and cost control. Asset management seeks effective and efficient long-term ownership of capital facilities via systematic acquisition, operation, maintenance, preservation, replacement, and disposition. Goals include optimizing life-cycle performance, minimizing life-cycle costs, and achieving maximum stakeholder benefit. Tools and techniques include design innovations, new construction technologies, materials improvements, geo-mapping, database management, value assessment, performance models, web-based communication, and cost accounting. Including asset management recognizes that civil engineers, during their careers, are likely to be involved with some aspect of capital facilities management.
14. an understanding of **business and public policy and administration fundamentals**.

*Commentary:* The professional civil engineer typically functions within both the public and private sectors that requires at least an understanding of business, public policy, and public administration fundamentals. Important business fundamentals topics as typically applied in the private, government and non-profit sectors include legal forms of ownership, organizational structure and design, income statements, balance sheets, decision (engineering) economics, finance, marketing and sales, billable time, overhead, and profit. Essential public policy and administration fundamentals include the political process, public policy, laws and regulations, funding mechanisms, public education and involvement, government-business interaction, and the public service responsibility of professionals.

15. an understanding of the **role of the leader and leadership principles and attitudes**.

*Commentary:* Leading, in the private and public arena— which differs from and complements managing— requires broad motivation, direction, and communication knowledge and skills. Attitudes generally accepted as being conducive to leadership include commitment, confidence, curiosity, entrepreneurship, high expectations, honesty, integrity, judgment, persistence, positiveness, and sensitivity. Desirable behaviors of leaders, which can be taught and learned, include earning trust, trusting others, formulating and articulating vision, communication, rational thinking, openness, consistency, commitment to organizational values, and discretion with sensitive information.

Of the four new outcomes defined by **CAP³** three (13, 14, and 15) require civil engineering faculty to become proficient in areas for which they may themselves have little or no formal education or training. The analogy of having a CE faculty member teaching a course in the principles of public policy might be akin to having an economist, who took and passed a course in statics and dynamics, teach the behavior of structural systems. The quandary we face as educators who are responsible for delivering this new content is: how can these new outcomes be effectively implemented with a faculty that may currently possess inadequate skills to communicate the concepts?

One obvious answer to this dilemma is to solicit the help of others, and perhaps the first person to turn to is the practitioner. The practitioner is the person who has had to wrestle with the issues of project planning and execution, business and public policy, and leadership on a daily basis to achieve success in the business world. Practitioners are valuable assets in communicating precepts of items 13-15 in the BOK. While practitioners may possess the requisite knowledge, they may not have the time or possess the organizational pedagogy necessary to effectively communicate that knowledge to our students. Another big issue is that they may not be given the full support of the institution in creating a curriculum that effectively melds all of these concepts. They, like many of their full-time teaching counterparts need help from both the institution and their academic peers with teaching effectiveness and curriculum development.

Another alternative is to solicit the help of other departments or agencies both on and off campus to fill in some of the voids in existing curriculums. This alternative clearly requires a
partnering with colleagues outside the discipline. It means that these colleagues must either teach service courses for which inadequate reward structures may in place or they must significantly modify existing syllabi to accommodate the civil engineering student. In all cases there must be close coordination between faculties of different programs.

Another possible alternative is to educate our current faculty in these new areas of emphasis which will require a diversion from many universities’ current definition of scholarship. The end result of all these alternatives is that university administrators must buy-in to this process of integrating practitioners, development of cross campus curriculums and redefining scholarship to insure the necessary faculty and programs are in place to insure success in delivering the BOK.

The Ideal Faculty Member

The heart of any institution and indeed any effort to implement the BOK is the faculty. As a result, the CAP\(^3\) also saw a need to define the attributes of the teacher of the BOK. The who section of the BOK, which is the real subject of this article attempted to define the principal characteristics of the ideal educator. The focus of CAP3 was on the individual faculty member in traditional “brick and mortar” universities. However, it is clear from the discussion above that the creation of the ideal faculty is as much an institutional responsibility as it is an individual responsibility. The ASCE Committee for Faculty Development is currently re-drafting the who section so that future versions of the BOK will also address the characteristics and responsibilities of the institution as well as faculty in delivering the BOK. The CAP\(^3\) initially defined the model civil engineering educator using four characteristics:\(^{[2]}\)

**Scholars:** Those who teach the civil engineering BOK should be scholars. Faculty should acquire and maintain a level of expertise in subjects they are teaching. Being a scholar mandates that engineering faculty be life-long learners, modeling continued growth in knowledge and understanding.

**Effective Teachers:** Student learning is optimal when faculty members effectively engage students in the learning process. The development of engineering faculty as effective teachers is critical for the future of the profession.

**Have Practical Experience:** Educators should have practical experience in engineering subjects that they teach. Most civil engineering faculty should hold professional engineering licenses.

**Positive Role Models:** Regardless of personal desires or choice, every civil engineer who is in contact with students serves as a role model for the profession. Engineering faculty should be aware that students are viewing them in that light. The ideal civil engineering faculty member should present a positive role model for our profession.

The committee recommended that every faculty member, full and part-time possess not one, but all of these characteristics. Of course the faculty member, as described by these attributes, very nearly fits Felder’s description of the “Superhuman Professor”\(^{[4]}\). With humor, Felder describes the mythical award winning teacher who was also a superlative researcher in both the technical and educational arenas, an expert consultant with many years of industrial experience and a
true leader in university governance and community service. Clearly, not all faculty can excel in all the areas describe here. In fact, fewer than 30% of the extant full time faculty at public and private institutions excel, even marginally, in all four areas. However, as Wankat says\cite{5}, “It is perfectly reasonable and possible to expect all professors to be good enough teachers in addition to excelling in at least one other area.” Gosick and Streveler\cite{6} contend that nearly 40% of undergraduate engineering courses in the US are taught by adjunct faculty or teaching assistants who are likely to be missing two or more of the four characteristics of the ideal faculty. By the same token many full time faculty have little practical experience and are ill equipped to teach some of the new skills in the BOK, such as contracts, ethics, and globalization of the engineering profession. As a result mechanisms must be put in place to assist the faculty of tomorrow to become proficient in all of the described characteristics. The following paragraphs discuss ways in which all four areas can be melded together to produce a balanced faculty member.

Scholarship

Many institutions have narrowly defined scholarship as the conduct of basic technical research. More specifically, faculty should be able to secure external funding and publish in important technical journals of the profession. Few will disagree that one of the most important precepts in academe is the ability of our professors to conduct technical research. Research results in the generation of new knowledge and it promotes the concept of life long learning. Faculty members remain abreast of a narrowly focused area of engineering through the conduct of technical research and as such this activity directly supports item 12 of the BOK. Perhaps most important from a student perspective, is the mentoring they receive when they are involved in the research. Unfortunately, technical research does not guarantee that faculty members will stay current with all aspects of their field nor does it guarantee that they will be good teachers in the classroom, which is where the bulk of the BOK will be delivered. While many argue that technical research can be directly related to good teaching the data does not support it\cite{7}. Faculty members who have a heavy research load may not be willing or even able to commit the necessary time to being a good teacher. Perhaps a more broadly defined definition of scholarship similar to that presented by Ernest Boyer\cite{8} would better serve the education of tomorrow’s engineers. Boyer supported the notion that scholarship could be defined in four broad areas; teaching, discovery, integration, and application. By taking a broader view of scholarship and by rewarding scholarship activities in all areas, institutions could promote a more diverse and effective faculty member who could in term deliver a more diverse graduate to the profession.

Effective Teaching

Few full time faculty and even fewer part time faculty receive formal education in teaching. The common belief has been that the technical PhD automatically qualifies one to teach a technical topic. Most engineering faculty today learned to teach by emulating an instructor they had in the past or by simply employing the trial and error approach. They pay little attention to how students learn or process the material. They don’t understand the value of a clear set of learning objectives and often their classroom choreography is lacking. As a result, one could conclude that many faculty members both tenure track and non-tenure track are ill equipped to teach effectively. In fact, in a study conducted by Seymour and Hewitt\cite{9} an
The overwhelming majority of math, science and engineering (MSE) students cited poor teaching as a major concern in their education and poor teaching was listed as the number one reason students left MSE programs. Clearly engineering programs have a need for more effective teachers. Joseph Lowman[10] has defined effective teaching using a 2-dimensional model which incorporates the concepts of intellectual excitement and interpersonal rapport. Exemplar teachers must possess high skills in both areas. Intellectual excitement is the act of presenting a clear and organized class which inspires students to think critically about a topic. Interpersonal rapport is the act of creating a caring atmosphere both in and out of the classroom. While interpersonal rapport takes some time to develop, skills that create intellectual excitement can be easily learned by new faculty. Lowman suggests that increasing intellectual excitement

The ASCE Committee on Faculty Development has instituted programs designed to assist faculty members in improving their teaching skills. The ASCE sponsored ExCEEd (Excellence in Civil Engineering Education) Teaching Workshop has been offered for the past five years as a week long vehicle designed to provide faculty the “nuts and bolts” tools they need to improve their status in the Lowman 2-D Model of effective college teaching.[10] Perhaps the key component of this workshop is instilling the “ExCEEd Teaching Model”, as illustrated in Fig. 1, in all participants. If participants can effectively implement this model they have established some improved level of intellectual excitement. Past participants in the ExCEEd workshops have reported that it represented a watershed event in their teaching careers. They could not believe that such simple concepts could have such an impact on their students learning and perception of their teaching. The committee has also sponsored mini-workshops called SEPTLs (Student Educator Practitioner Teaching and Learning) in which these concepts are introduced in an attempt to promote good teaching a wider audience of all potential faculty. It seems plausible that the concepts from these workshops could be used in graduate education.

A Framework for Teaching & Learning

| Provide an orientation: |
| Â· Why is this important? |
| Â· How does it relate to prior knowledge? |
| Provide learning objectives. |
| Provide information. |
| Stimulate critical thinking about the subject. |
| Provide models. |
| Provide opportunities to apply the knowledge: |
| Â· In a familiar context. |
| Â· In new and unfamiliar contexts. |
| Assess the learners’ performance and provide feedback. |
| Provide opportunities for self-assessment. |

Figure 1. The ExCEEd Teaching Model.

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courses in an engineering program to give future teachers and current TAs the tools they need to be effective teachers. Perhaps a new hiring policy for institutions should be that they require prospective faculty members to have undertaken some formal education courses in their program of study or have demonstrates a record of attending concentrated training sessions. These courses and workshops are readily available from a wide variety of sources and contribute significantly to teaching effectiveness. Perhaps ABET should require faculty to demonstrate that they are undertaking development activities that contribute to effective teaching.

Practical Experience

Engineer educators of the first half of the 20th century were practice oriented teachers who taught students how to apply basic principles of design to solve real problems. Many of these educators did not possess a doctorate, but instead had accumulated a wealth of practical experience in their field. They were active in the activities of their profession, and were considered valuable assets to society for their contributions to their communities and government. Unfortunately, some of these attributes may not be as pronounced in the engineering faculty of today. Many [10,11] have asserted that since the 1950s engineering education has migrated from applied, practice-oriented curricula to those that are dominated by basic math and science. In the quest for research dollars offered by a host of federal agencies after World War II universities have selected faculty members based on their capacity to perform basic research and publish, not on their teaching prowess or practical experience. While the infusion of basic principles was viewed as a positive in the 1950s and 1960s some felt that the pendulum had swung too far away from practice as early as the 1970s.[12] While the pendulum had begun to swing back to practice by the 1990s the reward system for faculty at most institutions remains ingrained in research dollars and publications. A recent survey of civil engineering department heads by Hoback and Dutta [13], in which the relative importance of research, teaching, service and experience are ranked, tends to reinforce this notion. They found that, at universities where graduate programs were offered, eternal funding and technical publications were ranked highest at 9+ on a 10 point scale. Teaching was ranked second but scored only 8 out of 10, while activities such as university, professional and community service scored between 3 and 4 out of 10. The least valued activities were those that lead to practical experience. They scored only 2 or less out of 10. Clearly, institutions do not currently buy into practical experience. If we are to bring practical experience to the classroom the activities leading to practical experience need to be valued and rewarded. In fact, a portion of a faculty member’s productivity rating should be devoted to developing practical experience.

Positive Role Model

Perhaps the most important overall precept of the four defining characteristics is Positive Role Model. Often, a student’s first exposure to the profession is through the formal educational process. It is the entry point to the profession where long-lasting attitudes, behaviors, and skills are formed early and serve to direct a student’s future decisions. Future teachers and their respective institutions play a crucial role in preparing the future civil engineer, and in this case, the learning of the BOK and its embedded values and ambitions. Whether it be the traditional academic lecturer, the virtual professor, or the adjunct practitioner, students understand faculty to be role models of the profession. The faculty member communicates who they are by their
conduct in an out of the classroom, by their work ethic, by their ethics in general, by their attitude to societal issues and by their professional reputation. Service at all levels clearly communicates to students the importance of becoming involved in activities that will affect their professional career and society in general.

The Obligations of the Educational Institution

Faculty, who are the acknowledged “heart of the educational program”, cannot effectively deliver the BOK alone. They need a “body” - the educational institution or organization – to support and guide the “heart”. And this institution today takes on many forms, ranging from the traditional brick and mortar university to the for-profit electronic entity. Although different in structure, each is similarly motivated by the notion of prosperity and the obligations of their missions. An institution that wishes to offer BOK programs has corresponding obligations; obligations to the faculty, to the students, and to the profession that, if adhered to, enable the accomplishment of the BOK. The institution must set priorities and supportive policies, adequately fund the infrastructure and personnel, assess quality, attend to standards, and recruit and retain students. Who, then, should the faculty and institutions of the BOK be? What will enable them, both individually and collectively, to be successful in facilitating the accomplishment of the BOK? The historical notion of institutional support is that it has an obligation to provide the faculty and students with adequate physical resources such as classrooms and laboratories. This notion is short sighted and will not guarantee that faculty will be capable of implementing the BOK or emulating the characteristics of the ideal faculty member. If faculty members are to develop in all four of the defining characteristics, the institution must acknowledge that there are different pathways for faculty success and demonstrate that faculty can be rewarded for taking paths other than the path of discovery. The institution must also support the development of faculty skills in teaching and in developing practical experience. The institution must also demonstrate a willingness to create new curricular content supported by new teaching and learning formats.

In regards to students the institution must be committed to excellence in the delivery of education at all times. It must insure that programs are in place that promote recruiting and retention of a diverse student population. The institution must also value diverse perspectives in education that include study of the liberal arts, tolerant attitudes and active inclusion of students and faculty in the shaping of the curriculum. The institution also has an obligation to the profession to produce graduates with technical, analytical, managerial and leadership attributes that will allow them to be productive in the short term but also allow them to reshape the world of the future in the long term.

Summary

The answer to “who should teach the civil engineering BOK?” is a faculty of scholars, all of whom have developed as effective teachers, have an appropriate level of practical experience, and are positive role models for the profession. In support of this faculty of scholars institutions have new responsibilities in revising reward systems, promoting diversity in student and faculty populations, supporting curricular change and faculty development in the scholarship of teaching and application.
References

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