

The Role of the Civil Engineering Body of Knowledge in ASCE's Raise the Bar Effort

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Horst Brandes has been involved with ASCE for many years. He has served as President of the Hawaii Section and as a Region 8 Governor. In addition, he has been a member of the Committee on Accreditation, the Committee on the Civil Engineering Technologist Body of Knowledge, the Committee on the Civil Engineering Body of Knowledge 3, and the Raise the Bar Committee. He is also a corresponding member of the Committee on the Civil Engineering Technologist. His interests in serving ASCE and the civil engineering profession include the academic and professional preparation of civil engineers, education, licensure, credentialing and advancing the profession.

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Mr. Flicker currently serves as an independent Senior Consultant with Pennoni Associates Inc. For 10 years prior, he was the Chief Financial and Administrative Officer, responsible for Accounting and Finance, Human Resources, Information Technology and Facilities.

He is a registered professional civil engineer with extensive background in developing municipal infrastructure projects, and has strong experience in project management and technical staff management for multi-disciplined projects.

His BS in Civil Engineering and MBA were both conferred by Lehigh University, Bethlehem, PA.

He has been a loyal supporter and leader in the engineering community. In addition to his extensive service to the American Council of Engineering Companies (ACEC) family, as past national Chairman, and in Pennsylvania, he has been President of the Hazardous Waste Action Coalition (of ACEC); a member of the American Society of Civil Engineers (ASCE), where he now serves as Chair of the Raise the Bar Committee; President of the Pennsylvania Society of Professional Engineers; Founding Chairman of the Pennsylvania Design Association Center; Past President of the Engineers' Club of Philadelphia; and Past President of the Philadelphia Engineering Foundation.

He currently serves on the Board of Directors of two prominent consulting engineering firms- a 900-person firm headquartered in Minneapolis and a 550-person firm headquartered in Florida and a \$25Million electronics distributor- headquartered in Pennsylvania.

In 2006, Mr. Flicker was named the Delaware Valley Engineer of the Year, as well as Civil Engineer of the Year by the American Society of Civil Engineers- Philadelphia Section.

He has also been active in the community. He is a Past President of the Board of Habitat for Humanity- the Affiliates in the Delaware Valley and served on the Board of the Chester County affiliate. He is also a past Board Member of both the Philadelphia Education Fund/ Philadelphia Scholars and the Public Citizens for Children and Youth (of southeastern Pennsylvania).

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Prior to joining ASCE, Kelly was a design engineer at Rathgeber/Goss Associates, a structural consulting firm in Rockville, MD, for nearly five years. As a structural engineer, she designed steel, masonry, concrete, and timber structures, analyzed existing buildings, and provided construction administration services.

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The Role of the Civil Engineering Body of Knowledge in ASCE's Raise the Bar Effort

Introduction

The Civil Engineering Body of Knowledge (CE-BOK) prescribes the necessary depth and breath of knowledge, skills, and attitudes required of any and all civil engineers entering the practice of civil engineering at the professional level. As Abbott [1] and others have indicated, the importance of the CE-BOK goes even further by laying a claim on the jurisdiction of civil engineering as a profession. Successful advocacy and defense of the jurisdiction carries with it the right to perform certain exclusive work on behalf of society. ASCE, as the lead civil engineering society, has made great efforts to publish and continuously update the CE-BOK precisely for these reasons. The third and most recent version of this body (CE-BOK3) has been drafted and it will be published shortly.

What this and previous versions of the CE-BOK reveal is that a standard ABET-accredited civil engineering baccalaureate degree provides insufficient academic preparation to enter civil engineering practice at the professional level. This implies the need for further post-graduate education, along with mentored experience in a professional setting and self-development, to fulfill the outcomes of the CE-BOK. In many respects, the newest version of the CE-BOK places even higher expectations on civil engineers than earlier versions. It is also clear that professional engineering (P.E.) licensure, as it exists in jurisdictions across the U.S., represents a bar that is significantly lower than the CE-BOK. The gap that remains between the expectations of the civil engineering profession and the reality imposed by largely intransigent licensing boards has been the driving focus of ASCE's Raise the Bar (RTB) effort. The Raise the Bar Committee within ASCE is tasked with closing this gap through education, communication and advocacy of the CE-BOK on all possible fronts. In response to the newest body of knowledge, the RTB Committee is preparing an action plan to do just that.

This paper summarizes the changes made to the CE-BOK between the 2nd and 3rd editions and explains how the CE-BOK is and always has been the foundation of ASCE's RTB effort. It will explore how ASCE has historically used the CE-BOK as a catalyst to influence change in the professional preparation of civil engineers, and how it may be used in the future. Potential hurdles to implementation will be shared, particularly considering significant changes that have been made. For example, CE-BOK3 has added an affective domain to some of its traditional cognitive outcomes, which no doubt will present a challenge for implementation. The three authors have been involved with RTB and CE-BOK activities within ASCE for many years and therefore this paper also provides an historical perspective and personal insight into current efforts to defend and advance the civil engineering profession.

The history of ASCE's Raise the Bar (RTB) initiative

Among engineering organizations, ASCE is and always has been the strongest advocate of the need for additional education and experience for entry into professional practice, extending beyond that provided by a traditional four-year baccalaureate degree. Engineering, like most

other learned professions, has faced a tremendous increase in the knowledge base needed to practice in today's world. While virtually every other learned profession has responded by increasing their educational requirements beyond four years, engineering has not done so. In fact, credit requirements for B.S. engineering degrees have actually decreased at many institutions over the last few decades.

The perceived lack of sufficient academic training has been a concern of ASCE's for at least the past 25 years. In 1995 ASCE held a civil engineering education conference, concluding that additional study beyond a baccalaureate degree was necessary for entry into professional practice [2]. A task committee was formed to determine a path forward, resulting in the 1998 initial formulation of Policy 465, which called for the "Master's degree as the First Professional Degree" necessary for licensure [3]. In order to implement the new policy, ASCE formed the Task Committee for the First Professional Degree (TCFPD, 1999-2001).

The requirement of a Master's degree faced significant pushback from within and outside ASCE. In response, Policy 465 was modified to state, "ASCE supports the concept of a Master's degree or equivalent as a prerequisite for licensure." A follow-up committee to TCFPD was constituted in 2001 to advance Policy 465 – the Committee on the Academic Prerequisites for Professional Practice (CAP³). This committee was particularly focused on evaluating what an "equivalent" path might consist of. It turns out that the proper answer could not be determined without developing the body of knowledge for civil engineering; i.e. what civil engineers ought to know at the point of entry into professional practice.

ASCE formed another task committee to undertake the significant research and scholarship necessary to develop a first version of the civil engineering body of knowledge (CE-BOK1). It was published in 2004 to widespread praise and acceptance. Implicitly, CE-BOK1 also defined the jurisdiction of the civil engineering profession as a whole [1], [4], [5]. It clearly spelled out that academic education alone would not suffice and that it should be accompanied by an experiential component to be achieved after graduation from a baccalaureate program. The new CE-BOK quickly took on a prominent role within the engineering community by influencing ABET criteria, and by encouraging the need for additional academic requirements as a prerequisite for licensure, and hence professional practice, by NCEES, NSPE and the National Academy of Engineering (NAE).

In response to the release of the CE-BOK1, Policy 465 was changed accordingly in 2004: "ASCE supports the attainment of a body of knowledge for entry into the practice of civil engineering at the professional level." The policy was again refined in 2007 to make it clear that fulfillment of the CE-BOK "requires additional education beyond the bachelor's degree for practice of civil engineering at the professional practice," although no mention was made of what specific advanced academic degree(s) or alternate pathways would be acceptable.

The civil engineering body of knowledge was updated in 2008 to reflect changes in the profession and shortcomings in the first version [6]. The new CE-BOK2 was formulated firmly within a Bloom's taxonomy framework [7], meaning that the expected knowledge (along with skills and attitudes) was prescribed in terms of a number of outcomes and corresponding levels of achievement specific to civil engineering. Common pathways for fulfillment are also

outlined, comprising of a bachelor's degree, a master's degree or equivalent, and pre-licensure experience. The term "or equivalent" is described in CE-BOK2 as "approximately 30 semester credits of acceptable graduate-level or upper-level undergraduate courses in a specialized technical area and/or professional practice area related to civil engineering." In response, Policy 465 was modified in 2010 to include similar language, calling for:

- a. a baccalaureate degree in civil engineering
- b. a master's degree in engineering, or no less that 30 coordinated graduate or upper level undergraduate technical and/or professional practice credits or the equivalent agency/organization/professional society courses which have been reviewed and approved as providing equal academic quality and rigor with at least 50 percent being engineering in nature
- c. appropriate experience based upon broad technical and professional practice guidelines which provide sufficient flexibility for a wide range of roles in engineering practice

When ASCE underwent reorganization in 2012, it created a new committee to replace CAP³, adopting the name Raise the Bar (RTB) for the new committee and the initiative as a whole. This occurred along with selection of RTB as one of the ASCE Board's three strategic initiatives.

In the years that followed, the RTB Committee worked hard trying to convince the community and licensing boards to adopt the key message of Policy 465, i.e. the need for additional education for entry into professional practice. The opposition, consisting of most other engineering disciplines, many individuals, and numerous licensing boards, worked hard to oppose ASCE's efforts. Supporting ASCE, at least to some degree through the adoption of policies and position statements acknowledging the need for advanced education, were NCEES, NSPE and the NAE. Between 2008 and 2016, ASCE initiated efforts to influence the educational requirements for licensure in four states – Nebraska, Connecticut, Vermont and New Jersey. ASCE was unsuccessful in convincing any of these licensing jurisdictions to change its educational requirements, despite significant expenditure of resources and time. This was a frustrating experience for those of us involved during this period of the RTB effort.

In 2016, the ASCE Board reconsidered the RTB initiative and decided to change course. It instructed the RTB committee to halt new lobbying of individual licensing boards and to explore new strategies to implementation of Policy 465. In response, the RTB committee submitted a new plan of action to the Board in March of 2018. The new approach, and indeed a new label for the Raise the Bar initiative, are discussed further below.

It should also be noted that in 2018, the ASCE Board adopted a new strategic plan, identifying six priority goals and related focus strategies to replace what were previously known as ASCE's "strategic initiatives," one of which was RTB. As a result, the ASCE Board reorganized its committee structure, so what were "strategic initiative committees" no longer report directly to the Board and instead are now constituent committees of other ASCE Society committees. The RTB committee was placed under the jurisdiction of the Committee on Advancing the Profession (CAP). This reorganization implicitly changed the strategic importance of RTB.

Two additional important developments have recently occurred. In March 2017, Policy 465 was changed to be “civil-centric”, in an effort to blunt opposition by other engineering disciplines and to make attainment of the CE-BOK even more explicit than before. In addition, another task committee completed work on the third edition of the civil engineering body of knowledge (CE-BOK3) in 2018.

The Third Edition of the Civil Engineering Body of Knowledge (CE-BOK3)

In October 2016, ASCE launched the Body of Knowledge 3 Task Committee and charged it to critically review published literature regarding the future of engineering, other disciplines and civil engineering practice; proactively solicit constituent input; evaluate the CE-BOK2; determine if a third edition of the civil engineering body of knowledge report is warranted; and, if warranted, develop the new report. After a review of the available literature, conducting a review of constituents, and engaging in internal deliberations, the consensus was that revisions to the CE-BOK2 were appropriate and justified and that the committee would move forward and develop a third edition of the body of knowledge (CE-BOK3). The final draft of the report has been completed and it will be released to the public in 2019 [8].

Starting with CE-BOK2, the task committee proceeded to consider both existing and possible new outcomes, based on the initial external survey, literature review, and an internal survey of task committee members. Pre-draft outcomes were prepared for further deliberation. Following a formal survey of constituents presented with these outcomes, a first draft of CE-BOK3 was developed to include outcome rubrics, level of achievement expected of each outcome, and typical pathways for fulfillment. These pathways include formal education, both at the undergraduate (UG) and post-graduate (PG) levels, and mentored experience (ME).

While the CE-BOK2 included 24 outcomes with descriptions in the cognitive domain only, CE-BOK3 consists of 21 outcomes. For the first time, CE-BOK3 includes description of 7 of these outcomes in the affective domain, in addition to the cognitive domain. This is an important change that recognizes the need for emotional or character development in order to function effectively in the professional world. The affective domain describes the manner in which individuals deal with interests, values, appreciation, enthusiasm, motivation and attitudes. In Bloom’s taxonomy, levels of development in the affective domain are also specified corresponding to different levels of achievement (5 in this case). In addition to UG and ME, self-development (SD) is considered necessary to reach the highest level of achievement in each of the affective domain outcomes. Table 1a provides a summary of the 21 outcomes that comprise the CE-BOK3 in the cognitive domain, and Table 1b includes a summary of the seven outcomes that are also defined in the affective domain. The cognitive outcomes are grouped into *Foundational* (1 – 4), *Engineering Fundamentals* (5 – 8), *Technical* (9 – 15) and *Professional* (16 – 21). Both tables also include the typical pathway to fulfillment.

Compared to the CE-BOK2, the CE-BOK3 changed in terms of the number of outcomes, their individual descriptions and typical paths for fulfillment. In some cases, individual outcomes were combined, dropped altogether or their names changed. For example, the “Experiments” outcome was changed to “Experimental Methods and Data Analysis” to place more emphasis on

evolving needs for data analysis skills in the civil engineering profession. A new outcome on “Critical Thinking and Problem Solving” replaces the previous outcome on “Problem Recognition and Solving”. The outcome on “Contemporary Issues and Historic Perspectives” was dropped altogether. Several of the professional outcomes were also modified. The description of many of the outcomes also changed substantially so that levels of achievement should not be compared between the second and third editions without considering changes to the outcome language. In the case of “Mathematics”, there is now an expectation of knowledge extending beyond calculus and differential equations to also include numerical methods. Each and every new aspect of the CE-BOK3 was arrived at based on extensive survey input and thoughtful internal deliberation.

It is important to note that the “Typical Pathway” denoted in Tables 1a and 1b is considered the most common way for an individual to achieve each outcome. However, this typical pathway is by no means the only path to fulfillment. By extension, attainment of specific academic degrees is not part of the CE-BOK3, although a bachelor’s degree in civil engineering or a closely related engineering discipline is strongly encouraged.

Table 1a. Cognitive Outcomes for CE-BOK3

Outcome	Level 1 Remember	Level 2 Comprehend	Level 3 Apply	Level 4 Analyze	Level 5 Synthesize	Level 6 Evaluate
1. Mathematics	UG	UG	UG			
2. Natural Sciences	UG	UG	UG			
3. Social Sciences	UG	UG	UG			
4. Humanities	UG	UG	UG			
5. Materials Science	UG	UG	UG			
6. Engineering Mechanics	UG	UG	UG			
7. Experm. Methods and Data Analysis	UG	UG	UG	PG		
8. Critical Thinking & Problem Solving	UG	UG	UG	ME	ME	
9. Project Management	UG	UG	ME			
10. Engineering Economics	UG	UG	ME			
11. Risk and Uncertainty	UG	UG	UG	ME		
12. Breath in Civil Engineering Areas	UG	UG	UG	ME		
13. Design	UG	UG	UG	ME	ME	
14. Depth in Civil Engineering Area	UG	UG	PG	PG	ME	
15. Sustainability	UG	UG	UG	ME		
16. Communication	UG	UG	UG	ME	ME	
17. Teamwork and Leadership	UG	UG	UG	ME	ME	
18. Lifelong Learning	UG	UG	UG	ME	ME	
19. Professional Attitudes	UG	UG	ME	ME		
20. Professional Responsibilities	UG	UG	ME	ME	ME	
21. Ethical Responsibilities	UG	UG	UG	ME	ME	

Table 1b. Affective Outcomes for CE-BOK3

Outcome	Level 1 Receive	Level 2 Respond	Level 3 Value	Level 4 Organize	Level 5 Characterize
15. Sustainability	UG	UG	ME	SD	
16. Communication	UG	UG	ME	SD	
17. Teamwork and Leadership	UG	UG	ME	SD	
18. Lifelong Learning	UG	UG	ME	SD	
19. Professional Attitudes	UG	UG	ME	SD	
20. Professional Responsibilities	UG	UG	ME	SD	
21. Ethical Responsibilities	UG	UG	ME	ME	SD

The requirement of specific academic degree(s) for entry into professional practice, such as a B.S. and/or M.S., is the subject of Policy 465. The specific degree requirements have been deliberated extensively within and outside the civil engineering profession; this is reflected in the continuing evolution of Policy 465. The policy is currently undergoing revision once again by the RTB committee to make it even more focused on attainment of the CE-BOK, rather than on setting expectations for licensure. In part, this is due to the recognition by ASCE of its limited influence in changing legal licensure requirements across the patchwork of jurisdictions in the United States.

The Role of the CE-BOK3 in Shaping the Future of the RTB Initiative

The role of the CE-BOK in the RTB effort is highlighted in the committee’s report to the ASCE Board in March 2018, stating that [9]:

The American Society of Civil Engineers (ASCE), as the acknowledged leader of the civil engineering profession, has a responsibility to establish and advance standards to fulfill its mission to protect the public health, safety, and welfare. This responsibility includes the establishment of a body of knowledge (CE-BOK) to describe the minimum knowledge, skills, and attitudes necessary for professional practice. ASCE has determined there is a significant gap between the CE-BOK and the current educational and experiential requirements for entry into the professional practice of civil engineering. Additional education and relevant experience is required for the future civil engineer. Otherwise, civil engineering is at risk of losing relevance and its place as a learned profession.

Going forward, the RTB initiative intends to change course by more broadly taking on the task of educating and advocating for attainment of the CE-BOK by all civil engineers entering practice at the professional level. The CE-BOK implies that such preparation requires undergraduate and graduate education, mentored experience, and self-development preparation, going beyond what is currently required by licensing boards across the country. When the need

for advanced education is proposed to the civil engineering community at large, most practitioners agree that this is desirable and indeed necessary in today's world. Much of the enthusiasm comes from younger civil engineers when the issue is posited as voluntary rather than a legal mandate for licensure. In fact, in a recent ASCE survey, 84% of student respondents indicated they are pursuing or plan to pursue a graduate degree. The need for advanced education is especially relevant in the civil engineering profession given the unique high level of responsibility that society has placed on civil engineers to protect the health, safety and welfare of the public.

One of the perceived shortcomings of the RTB initiative is the name of the initiative itself. Many individuals associate RTB with past efforts to change licensing laws that impose additional requirements for professional practice not only for civil engineering but also for most other disciplines as well. As a result, the RTB committee has embarked on a rebranding effort to develop a new identity. A consultant has been retained to carry out this task and preliminary options were presented to the RTB committee. As a result, the label "Raise the Bar" will be retired. For the most part, the proposals that were received focused on portraying a forward-looking and optimistic view of the issue. The RTB committee has adopted the new name "Engineer Tomorrow", along with the tagline "Knowledge for a Changing World." The rebranding effort will be followed by a communications plan to reach stakeholders as widely as possible.

Given that licensing laws currently fall short of the knowledge base necessary per the CE-BOK3, ASCE is studying how certification may be used to validate fulfillment of the CE-BOK. One idea being explored is to develop a system of Board certifications, in some ways similar to the medical profession. Such a certification could then be considered as evidence of having gained the knowledge base – both the breadth and depth - necessary for entry into the practice of civil engineering, as deemed adequate by ASCE. Such a certification would imply a higher level of achievement than a professional engineering license.

The RTB committee, under its new name, will need to guide periodic updating of the CE-BOK. A revision cycle of 8 years appears to be adequate. In the meantime, much work regarding the CE-BOK remains to be completed. A series of guides for students, academics and practitioners will need to be developed in cooperation with the ASCE Committee on Education. Assessment methods will have to be considered as well. This will be a challenging proposition especially for the new affective outcomes. Standard testing methods may not prove very effective in this case and assessment may need to rely more heavily on mentor evaluations and perhaps project portfolios of some type.

Conclusions

The Raise the Bar initiative has undergone significant evolution since Policy 465 was first introduced in 1998. Initial efforts to implement the policy were focused almost exclusively on changing licensing laws across the United States and this met with significant adversity and a lack of success. More recently, the consensus within ASCE has been to shift emphasis toward achievement of the CE-BOK for entry into practice of civil engineering at the professional level. Given the gap that exists between licensure requirements and the CE-BOK3, the initiative is now

embarking on efforts to disseminate the CE-BOK3 as broadly as possible to encourage civil engineers entering practice at the professional level to seek the advanced education necessary to achieve the preparation necessary to function effectively today and tomorrow. Clearly then the CE-BOK3 is taking on a more important role than ever before in defining the civil engineering profession and as a repository of the knowledge base necessary for successful civil engineering practice.

References

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