ASCE'S Body of Knowledge: Preparing for the Future[a]

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When we build,
let it not be for present use alone.
Let it be such work as our
descendants will thank us for.
(John Ruskin, English philosopher)

Background

Today's world is fundamentally challenging the way civil engineering is practiced. Complexity arises in every aspect of projects, from pre-project planning with varied stakeholders to building with minimum environmental and community disturbance. A 2001 ASCE report *Engineering the Future of Civil Engineering* (www.asce.org/raisethebar) highlighted the significant and rapid changes confronting the profession, while recent events have demonstrated our vulnerability to human-made hazards as well as natural disasters. The risks and challenges to public health, safety, and welfare will continue to escalate in complexity, and the civil engineering profession must respond proactively. The 2001 report also concluded that the current four-year bachelor's degree is becoming inadequate formal academic preparation for the practice of civil engineering at the professional level in the 21st century.

Recognizing the preceding and in keeping with the leadership role of civil engineers in the infrastructure and environmental arena, the ASCE Board of Direction acted. In November 2001, this fundamental issue facing the civil engineering profession led to the adoption by the Board of ASCE Policy 465 which "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." The Board believed that education beyond the current bachelor's degree was needed to adequately prepare engineers for practice.

The American Society of Civil Engineers (ASCE) created the Task Committee on Academic Prerequisites for Professional Practice (TCAP[3]) in October 2001 and charged it to "… develop, organize and execute a detailed plan for full realization of ASCE Policy Statement 465." The policy's essence is that ASCE supports the concept of a master's degree or equivalent as a requirement for licensure and the practice of civil engineering at the professional level. (In November 2003, in recognition of the long-term nature of

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implementing Policy Statement 465, TCAP[3] was changed to the Committee on Academic Prerequisites for Professional Practice [CAP[3]], a permanent Board-level committee.)

TCAP [3] developed an implementation master plan with the Body of Knowledge (BOK) as the foundation. Therefore, the BOK Committee was formed and charged with defining the BOK needed to enter the practice of civil engineering at the professional level (licensure) in the 21st Century.

The BOK will be used to measure an aspiring civil engineer's preparation for licensure and practice of civil engineering at the professional level. The charge to the BOK Committee included addressing the role of experience and describing the responsibilities of full or part-time faculty, practitioners, and students in fulfilling the BOK.

Purpose of Paper

The purpose of this paper is to present an overview of the First Edition of the ASCE Body of Knowledge. The BOK follows three themes:

- ***what*** should be taught and learned,
- ***how*** it should be taught and learned, and
- ***who*** should teach and learn it.

Body of Knowledge – *What* Should Be Taught and Learned?

Outcomes are the principal means of defining the ***what*** dimension of the civil engineering BOK for the 21st Century. The BOK consists of 15 outcomes that build on the 11 outcomes promulgated by the Accreditation Board for Engineering and Technology (ABET). In addition to the 11 ABET outcomes, which are included verbatim in the 15 BOK outcomes, four entirely new outcomes (Outcomes 12-15) address technical specialization, project management, construction, asset management, business and public policy and administration, and leadership. Commentaries are provided and competency levels are specified for all outcomes.

Relative to today's basic programs, the outcomes collectively prescribe the knowledge, skills, and attitudes of an individual aspiring to the practice of civil engineering at the professional level (licensure) in the 21st Century. Accordingly, The 21st Century civil engineer must demonstrate each of the following 15 outcomes:

1. **an ability to apply knowledge of** mathematics, science and engineering.
2. an ability to design and conduct **experiments**, as well as **analyze** and **interpret** data.

3. an ability to **design** a system, component or process to meet desired needs.
4. an ability to function on **multi-disciplinary teams**.
5. an ability to identify, formulate and solve **engineering problems**.
6. an understanding of **professional and ethical responsibility.**
7. an ability to **communicate** effectively.
8. the broad education necessary to understand the **impact of engineering solutions** in a global and societal context.
9. a recognition of the need for, and an ability to engage in, **life-long learning.**
10. a knowledge of **contemporary issues.**
11. an ability to understand the techniques, skills, and modern **engineering tools** necessary for engineering practice.
12. an ability to apply knowledge in a **specialized area related to civil engineering**.
13. an understanding of the elements of **project management, construction, and asset management.**
14. an understanding of **business and public policy and administration fundamentals**.
15. an understanding of the **role of the leader** and **leadership principles and attitudes.**

Body of Knowledge – *How* Should It Be Taught and Learned?

Having defined ***what*** constitutes the BOK, the Committee considered ***how*** it should be taught and learned. The teaching/learning modes are:

- Undergraduate study typically leading to a BSCE;
- Graduate study or equivalent;
- Co-curricular and extra-curricular activities; and
- Post-BS engineering experience prior to licensure.

The Committee concluded that the BSCE will be the means of initiating the teaching and learning of all outcomes. Furthermore, based on the breadth and depth of knowledge, skills, and attitudes covered through that course of study, that BSCE could provide an attractive and appropriate liberal education for the 21st Century both for those on an engineering track and for those aspiring to other professions.

Both upper level undergraduate and graduate-level education, or its equivalent, and structured post-BS experience are essential to achieving the BOK. Requisite competency for ten of the 15 outcomes is achieved by adding experience to the educational components of a student's learning.

While structured post-BS experience is essential, experience interspersed within formal education is valuable. Additionally, the student's formal education can be significantly enhanced by participation in extra-curricular activities.

The Committee began searching for existing undergraduate-graduate programs that approximate, in terms of outcomes, the BOK defined in this report. Additionally, the Committee has begun working with selected civil engineering departments that want to be leaders in designing bachelor's/master's degree tracks that will provide the prescribed BOK within the framework of each institution's culture, traditions, and strengths.

The first nine departments to join this effort, in the order in which they joined, include Colorado State University; Iowa State University; Case Western Reserve University; Bucknell University; Western Michigan University; California State University, Los Angeles; Rose-Hulman Institute of Technology; University of Louisville; and Wentworth Institute of Technology. Currently there are over 20 schools participating.

These schools have found that all of the outcomes of the recently expanded Body of Knowledge (i.e., outcomes 13, 14, and 15) can be covered within the undergraduate curriculum, with the exception of Outcome 12, additional technical depth. The additional technical depth component would, by its very nature, be very flexible in its application to allow for a wide range of career paths. Under this situation, the post-BS engineering education would consist of upper level undergraduate or graduate level coursework in professional practice and/or technical topic areas.

The Committee has concluded that distance learning, especially that which is web-based, will increasingly provide an effective means for developing the knowledge, skills, and attitudes included in the BOK. Finally, the Committee expects that the majority of civil engineers seeking licensing will follow a path that leads from an EAC/ABET-accredited baccalaureate through an accredited engineering master's degree. Validating attainment of the BOK through an EAC/ABET baccalaureate and approximately 30 hours of upper level undergraduate work plus graduate work will be more complex, but provides another alternative to achieving the requisite BOK.

Body of Knowledge – *Who* Should Teach and Learn It?

The following four characteristics of the model civil engineering faculty member are evident to the BOK Committee:

- ***Scholars:*** Those who teach the civil engineering BOK should be scholars. Faculty should acquire and maintain a level of expertise in the subjects that 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.

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

- ***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. Those who teach should be aware that students are viewing them as such. The ideal civil engineering faculty member should present a positive role model for our profession.

These are explicit success factors for those who will teach 21st Century civil engineers. They reflect the need and the opportunity to raise the bar in all three dimensions of the civil engineering BOK—the ***what***, the ***how***, and the ***who***.

Although civil engineering faculty and practitioners must be instrumental in advocating and teaching the BOK necessary for 21st century professional practice, civil engineering students ultimately have the primary responsibility for their own education. Students must be committed to excellence in their education. Success in the study and eventual practice of civil engineering is likely to be enhanced if a person's aptitudes, interests, and aspirations resonate with the unique and special attributes of civil engineering.

The Next Steps

While the First Edition of the BOK is now complete, updates are likely and will be prepared as needed. The report is available at the ASCE website: www.asce.org/raisethebar.

Building on the BOK foundation, the Curricula Committee is finding and creating programs that will help to fulfill the BOK and the Accreditation and Licensure Committees are moving forward in essential Policy Statement 465 implementation

efforts. The BOK is also being incorporated into the implementation of the ASCE specialty certification program.

Closing Thoughts

Defining the ***what, how,*** and ***who*** of the BOK needed to enter the practice of civil engineering at the professional level (licensure) in the 21st Century was challenging, but also satisfying, because implementation of the BOK will markedly strengthen the CE profession. ASCE fully recognizes that expanding the civil engineering BOK through additional education and enhanced experience, as a prerequisite for licensure, probably cannot be fully implemented without affecting other engineering disciplines. Engineering licensure in the U.S. is typically generic, rather than discipline-specific, and education and experience requirements are generally the same for all engineering disciplines. The ASCE encourages societies representing other engineering disciplines to consider the necessity for and ramifications of "raising the bar" in the long-term interest of maintaining public health, safety, and welfare.

According to ASCE's vision, newly licensed civil engineers will possess a broader and deeper suite of knowledge, skills, and attitudes that will enable them to more effectively function in the highly challenging civil engineering environment of the coming decades. They will be better prepared to:

- Hold paramount public safety, health, and welfare,
- Participate in the formulation of—as well as the implementation of—programs and projects related to their expertise,
- Guard the natural environment and create a sustainable built environment,
- Conceive, plan, design, and manage large civil infrastructure systems including transportation, water, wastewater, structures, land use, energy, and security,
- Integrate an increasingly diverse workforce,
- Lead global technology development and transfer, and
- Grow personally and professionally throughout their careers.

In closing, let us consider the words of one of our most prominent engineers:

It is a great profession.
There is the fascination of watching a figment of the imagination emerge through the aid of science to plan on pages.
Then it brings jobs and homes…

it elevates the standard of living and adds to the comfort of life.
That is the engineer's high privilege.
(Herbert Hoover, engineer, author,
humanitarian and 31st U.S. President)

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