

Executive Summary

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 and disasters. The risks and challenges to public safety, health, 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 preparation 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.

Today's world is fundamentally challenging the way civil engineering is practiced. The current four-year bachelors degree is becoming inadequate for the professional practice of civil engineering.

The Task Committee on Academic Prerequisites for Professional Practice (TCAP³) was charged with developing, organizing, and executing a plan to implement ASCE Policy Statement 465.

TCAP³ developed an implementation master plan for which the Body of Knowledge (BOK) was the foundation.

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The BOK has what, how and who elements.

The American Society of Civil Engineers (ASCE) created the Task Committee on Academic Prerequisites for Professional Practice (TCAP³) in October 2001 and charged it to "... develop, organize and execute a detailed plan for full realization of ASCE Policy Statement 465." The essence of the policy 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 implementing Policy Statement 465, TCAP³ was changed to the Committee on Academic Prerequisites for Professional Practice [CAP³], a permanent Board-level committee.)

TCAP³ developed an implementation master plan for which the Body of Knowledge (BOK) was 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 prepare an aspiring civil engineer 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 Report

The purpose of this report is to present the recommendations of the BOK Committee and, secondarily, to describe the process used to arrive at those recommendations. The Committee's recommendations follow these three themes:

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

The Committee's primary effort was the *what*. CAP³ and its constituent committees will refine the *what* and focus on further developing the *how* and *who*.

Committee Approach

The BOK Committee took a future-oriented approach encompassing infrastructure and environmental problems and opportunities for future decades. The committee approach included making a broad interpretation of practice to include many roles and functions. Institutional and individual flexibility was stressed. Committee correspondents were used to solicit concerns and ideas and to critique draft materials. Committee members proactively participated in key conferences and workshops and presented and published papers and articles to expand interaction with stakeholders.

The BOK Committee's approach was future-oriented and involved intensive interaction with stakeholders.

BODY OF KNOWLEDGE

What Should Be Taught and Learned?

The committee selected an outcomes approach as the principal means of defining the *what* dimension of the civil engineering BOK for the 21st century. Relative to today's basic programs, the outcomes collectively prescribe a substantially greater depth and breadth of knowledge, skills, and attitudes required of an individual aspiring to the practice of civil engineering at the professional level (licensure) in the 21st century. The 15 outcomes include and begin with the 11 outcomes of the Accreditation Board for Engineering and Technology (ABET) and prescribe more technical depth and additional breadth. The 21st century civil engineer must demonstrate:

The recommended 15 outcomes for tomorrow's civil engineer broaden and deepen ABET's current 11 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.

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.

Knowledge and skill, while necessary, are not sufficient to be a fully functioning professional civil engineer. A civil engineer's attitude, that is, the manner in which he or she approaches his or her work, will determine how effectively he or she uses hard-earned knowledge and skills. Accordingly, attitudes are an essential part of the BOK. Aspects of attitudes addressed by the committee and presented in this report include the definition and impact of attitudes, examples, the wide range of viewpoints regarding teaching about attitudes, and the relationship between attitudes and outcomes.

Attitudes are an essential part of the BOK.

Formal undergraduate education, graduate study or equivalent, co- and extra-curricular activities, and experience will be used to fulfill the BOK.

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 a BSCE would be the means of initiating the teaching and learning of all outcomes. Furthermore, based on its breadth and depth of knowledge, skills, and attitudes, that BSCE could provide an attractive and appropriate liberal education for the 21st century both for those on an engineering track and 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 fifteen 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 began 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 ten departments to join this effort, in the order in which they joined, are at 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; Wentworth Institute of Technology; and University of Oklahoma.

The committee concludes 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 ABET/EAC-accredited baccalaureate through an accredited engineering master's degree. Validating attainment of the BOK through an ABET/EAC baccalaureate and approximately 30 hours of upper level undergraduate work plus graduate work will be more complex.

Curricula design projects are a step toward implementation of the BOK.

Distance learning will increasingly improve accessibility to high quality formal education.

BODY OF KNOWLEDGE

Who Should Teach and Learn It?

Tomorrow's civil engineering faculty members should be scholars, effective teachers, positive role models, and have practical experience.

The following four characteristics of the model full or part-time 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 they teach. 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 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 view them in that light. 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 the 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 personal aptitudes, interests, and aspirations resonate with the unique and special attributes of civil engineering.

The success of tomorrow's civil engineering students will be enhanced if their aptitudes, interests, and aspirations resonate with the unique and special attributes of civil engineering.

The Next Steps

Having completed its work with the publication of this report, the BOK Committee has been disbanded. While this report is now completed in its first edition, updates are likely and will be prepared as needed. The current version of this report is available at the ASCE website (www.asce.org/raisethebar).

Building on the BOK foundation, the newly formed 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 presented in this report is also being used in implementation of the ASCE specialty certification program.

Closing Thoughts

ASCE recognizes that expanding the civil engineering BOK through additional education and enhanced experience, as a prerequisite for licensure, probably cannot be fully implemented without somewhat similar modifications 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 also consider the necessity for and ramifications of “raising the bar” in the long-term interest of maintaining public safety, health and welfare.

The BOK Committee thanks TCAP³ and the ASCE Board of Direction for the opportunity to serve. 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 civil engineering profession.

Increasingly, 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,

The work of the Accreditation, Curricula and Licensure Committees, as well as the initial implementation of ASCE's specialty certification, is building on the BOK.

The ASCE encourages societies representing other engineering disciplines to also consider the necessity for and ramifications of “raising the bar” in the long-term interest of maintaining public safety, health and welfare.

The BOK will prepare tomorrow's licensed civil engineers to proactively function in the challenging national and global environment of the coming decades.

- 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.

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 paper. 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