

## **Development of the 3<sup>rd</sup> Edition of the ASCE Body of Knowledge**

Norb Delatte P.E., Ph.D., F.ACI, F.ASCE, M.R. Lohmann Endowed Professor of Engineering and Head, School of Civil and Environmental Engineering, Oklahoma State University

### **Abstract**

The American Society of Civil Engineers (ASCE) has formed a committee to develop a 3<sup>rd</sup> edition of the Civil Engineering Body of Knowledge (BOK3), to build on the first and second editions. Over the past year the BOK3 committee has been researching the literature and conducting surveys to analyze the current state of outcomes and develop possible new outcomes. The earlier BOK editions have led to changes in the ABET program criteria for civil engineering programs. Following the changes to accreditation criteria based on the BOK2, it was determined that the civil engineering program criteria, and thus the BOK, should be updated periodically. Work is currently under way on the BOK3 and publication is expected in late 2018.

### **Introduction**

The American Society of Civil Engineers (ASCE) published its first edition of the Body of Knowledge (BOK) in 2004 (ASCE 2004). The ASCE BOK was outcome based, and was in part intended to facilitate the ASCE Policy Statement 465 toward the Master's degree or equivalent as an academic prerequisite for licensure (ASCE 2017a). This is now termed the Raise the Bar initiative (ASCE 2017b).

The first edition BOK had 15 outcomes. The first 11 were identical to the ABET Criterion 3 student outcomes a – k at the time (ABET 2004). The additional four were:

- Specialized area related to civil engineering,
- Project management, construction, and asset management
- Business and public policy, and
- Leadership

### **Development of the 2<sup>nd</sup> Edition Body of Knowledge (BOK2)**

Subsequent to the publication of the BOK, in 2006 ASCE convened a summit on the Future of Civil Engineering – 2025. This resulted in the report “The Vision for Civil Engineering in 2025” (ASCE 2007). Based on feedback on the original BOK, and in order to better implement the Vision, Raise the Bar, and other ASCE initiatives, a committee was formed to develop a second edition of the body of knowledge, or BOK2, which was published in 2008 (ASCE, 2008).

The BOK2 differed from the original BOK in several significant ways. The number of outcomes was expanded from 15 to 24, divided into three categories, Foundational, Technical, and Professional. The BOK2 also mapped each outcome to a level of achievement based on Bloom's taxonomy. The levels of achievement, 1 through 6, are defined as Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation.

The BOK2 was intended to be fulfilled at the point of licensure as a Professional Engineer. In agreement with the Raise the Bar initiative, this includes the bachelor's degree (B), a master's degree or equivalent (M/30, defined as approximately 30 semester credit hours of acceptable upper level or graduate courses in technical or professional topics), and prelicensure experience (E). This is shown in Figure 1, taken from Figure ES-1 of the BOK2 (p. 3 ASCE 2008).

Figure 1: BOK2 outcomes and levels of achievement (ASCE 2008)

Outcome Number and Title	Level of Achievement					
	1 Knowledge	2 Compre- hension	3 Application	4 Analysis	5 Synthesis	6 Evaluation
<i>Foundational</i>						
1. Mathematics	B	B	B			
2. Natural sciences	B	B	B			
3. Humanities	B	B	B			
4. Social sciences	B	B	B			
<i>Technical</i>						
5. Materials science	B	B	B			
6. Mechanics	B	B	B	B		
7. Experiments	B	B	B	B	M/30	
8. Problem recognition and solving	B	B	B	M/30		
9. Design	B	B	B	B	B	E
10. Sustainability	B	B	B	E		
11. Contemp. issues & hist. perspectives	B	B	B	E		
12. Risk and uncertainty	B	B	B	E		
13. Project management	B	B	B	E		
14. Breadth in civil engineering areas	B	B	B	B		
15. Technical specialization	B	M/30	M/30	M/30	M/30	E
<i>Professional</i>						
16. Communication	B	B	B	B	E	
17. Public policy	B	B	E			
18. Business and public administration	B	B	E			
19. Globalization	B	B	B	E		
20. Leadership	B	B	B	E		
21. Teamwork	B	B	B	E		
22. Attitudes	B	B	E			
23. Lifelong learning	B	B	B	E	E	
24. Professional and ethical responsibility	B	B	B	B	E	E

For each of the outcomes, a rubric was developed to define all six levels of achievement, even if a lower level of achievement was anticipated at the time of licensure. For example, Outcome 1 Mathematics is only expected to reach level 3, Application, during the bachelor's degree, with no additional levels during M/30 or E, but all six levels of achievement were defined in the associated rubric nevertheless. The rubrics were intended to make it easier to determine if a specific outcome had been achieved.

The BOK2 also had extensive appendices to document the scholarly research behind the outcomes and to define them further.

Bloom's taxonomy consists of a three domains, the cognitive, the affective, and the psychomotor. The bulk of the BOK2 work focused on the cognitive domain, since that refers directly to knowledge. It was, however, recognized that for some objectives the affective domain might also be appropriate. "The affective domain includes objectives that describe changes in interest, attitudes, and values and is an inseparable complement. Progress in the affective domain is described in terms of internalization of values." (p. 87, ASCE 2008).

The affective domain has five levels of achievement, Receiving, Responding, Valuing, Organization, and Characterization by a value complex. The BOK2 committee prepared affective domain rubrics for two outcomes, Outcome 16 Communication and Outcome 24 Professional and Ethical Responsibility.

The BOK2 committee concluded, in a section entitled Future Work, that "An affective domain supplement to the BOK2 cognitive descriptions is possible and desirable... Accordingly, the BOK2 Committee recommends that departments, schools, employers, and professionals develop these ideas more fully." (p. 97, ASCE 2008).

### **Impact on Accreditation Criteria**

The BOK2 was subsequently used to revise the ABET program criteria for civil engineering and similarly named programs. ABET program criteria can address faculty and curricular requirements, but the BOK2 focused on the curriculum.

For programs with accreditation visits in the 2010-2011 cycle, the new program criteria were: "The program must demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure." (p. 10, ABET 2010).

The major change was the requirement for an additional science, such as geology or biology. This change caused some disruption for programs that did not already include a third science and had to add it, often requiring removal of another course.

The curriculum requirements also changed for accreditation visits in the 2016- 2017 cycle. These new program criteria were: "The curriculum must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science; apply probability and statistics to address uncertainty; analyze and solve problems in at least four technical areas appropriate to civil engineering; conduct experiments in at least two technical areas of civil engineering and analyze and interpret the resulting data; design a system, component, or process in at least two civil engineering contexts; include principles of sustainability in design; explain basic concepts in project management, business, public policy, and leadership; analyze issues in professional ethics; and explain the importance of professional licensure." (p. 11, ABET 2016).

In this case, the major changes were the application of probability and statistics to address uncertainty, and inclusion of principles of sustainability in design. These flowed directly from Outcome 10 Sustainability and Outcome 12 Risk and Uncertainty in the BOK2. These two changes prompted considerable discussion and feedback among the ASCE department head's community. The end result of the discussion was some relaxation of the requirements from what had been originally proposed.

### **Formation of the 3<sup>rd</sup> Edition Body of Knowledge Committee**

Following the changes to accreditation criteria based on the BOK2, it was determined that the civil engineering program criteria, and thus the BOK, should be updated periodically. Since programs are reviewed on a six year cycle, a revision cycle greater than six years was suggested so that the same programs would not always be the first to undergo accreditation reviews under the new criteria.

The agreed upon revision cycle was eight years. Since BOK2 was published in 2008, this implied a third BOK published in 2016, which was obviously not possible. ASCE sent out a call for volunteers to start work on a possible BOK3 convening in October 2016 with the responsibility to complete work by September 2018.

Potential volunteers for the BOK3 committee met in Reston, Virginia in early August 2016 with the task of determining whether a 3<sup>rd</sup> edition of the BOK was warranted, and if so what form it might take. The committee has representatives from both academia and practice, and the extensive member and corresponding member roster is listed on the ASCE BOK web site (2107c).

The committee's review included Body of Knowledge documents such as the National Society of Professional Engineers (NSPE), the American Institute of Chemical Engineers (AIChE), and the American Academy of Environmental Engineers (AAEE), nearly all of which were developed after the ASCE BOK2. Other important documents included the 2013 Graduate Attributes and Professional Competencies from the International Engineering Alliance (IEA 2013) and the US Department of Labor Engineering Competency Model (USDOL undated). Scholarly papers presented at the various American Society for Engineering Education (ASEE) were also reviewed. In light of these developments, the committee concluded that developing a BOK3 was warranted.

The work proceeded with a combination of face to face meetings and weekly conference calls, including the official committee members and a large number of corresponding members. A survey of constituents was carried out to evaluate the relevance of the existing outcomes and some proposed outcomes. The survey addressed the importance of each outcome, as well as how well each outcome statement was drafted. Obviously, outcomes that were rated as important but poorly worded would be the most important candidates for revision of outcome statements. BOK2 outcomes that were judged to be less important would be candidates for deletion from the BOK3.

After considerable discussion, the committee decided to retain the outcome based approach. The next step was to undertake an in depth review of each outcome, including supporting information from sources such as the IEA and the USDOL. Then, for each existing or proposed outcome, a revised rubric was developed in the cognitive domain. Where appropriate, rubrics were also developed in the affective domain, recognizing that some outcomes might even shift exclusively to the affective domain, for example, the BOK2 Outcome 22 Attitudes. The committee took very seriously the BOK2 comment on the work needed in the affective domain.

The current progress of the effort is documented on the ASCE BOK web site:

“What’s been completed:

- Literature search and review: Fall 2016
- Review of BOK 2nd edition outcomes, Round 1: Winter 2016-17/Spring 2017
- Survey of stakeholders, Part I: Winter 2016-17

What’s in progress:

- Proposals and review of additional outcomes: Spring/Summer 2017
- Review of BOK 2nd edition outcomes, Round 2: Spring/Summer 2017

What’s just around the corner:

- Survey of stakeholders, Part II: Summer 2017
- Review of all outcomes, Round 3: Summer/Fall 2017
- Progress Report to ASCE Board of Direction: October 2017
- Distribution of draft report to stakeholders: Winter 2017-18” (ASCE 2017c)

The plan puts in milestones to solicit stakeholder input to influence BOK3 development.

## **Summary and Conclusions**

The first two editions of the civil engineering Body of Knowledge have been very useful for defining and developing the profession. The documents have had a significant impact on civil engineering education, including the two most recent revisions to program accreditation criteria.

The profession is changing, and the challenges of 2017 are not the same as those of 2004. The development of the BOK3 recognizes this fact, and sets in motion an eight year cycle for updating the Body of Knowledge as well for civil engineering program criteria.

## **References**

ABET Inc., (2004) Engineering Accreditation Commission, Criteria for Accrediting Engineering Programs, Effective for Evaluations During the 2004-2005 Accreditation Cycle, Baltimore, Maryland

ABET Inc., (2010) Engineering Accreditation Commission, Criteria for Accrediting Engineering Programs, Effective for Evaluations During the 2010-2011 Accreditation Cycle, Baltimore, Maryland

ABET Inc., (2016) Engineering Accreditation Commission, Criteria for Accrediting Engineering Programs, Effective for Evaluations During the 2016-2017 Accreditation Cycle, Baltimore, Maryland

ASCE (2004) Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century: Preparing the Civil Engineer for the Future, Reston, VA.

ASCE (2008) Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century: Preparing the Civil Engineer for the Future, Second Edition, Reston, VA.

ASCE (2017a) Policy Statement 465 – Academic Prerequisites for Licensure and Professional Practice, Approved by Board of Direction March 17, 2017, <http://www.asce.org/issues-and-advocacy/public-policy/policy-statement-465---academic-prerequisites-for-licensure-and-professional-practice/> accessed May 30, 2017

ASCE (2017b) Raise the Bar, [http://www.asce.org/raise\\_the\\_bar/](http://www.asce.org/raise_the_bar/), accessed May 30, 2017

ASCE (2017c) Civil Engineering Body of Knowledge [http://www.asce.org/civil\\_engineering\\_body\\_of\\_knowledge/](http://www.asce.org/civil_engineering_body_of_knowledge/), accessed May 30, 2017

International Engineering Alliance (IEA) ( 2013) Graduate Attributes and Professional Competencies Version 3: 21 June 2013 available at <http://www.ieagrements.org>.

US Department of Labor (USDOL) (undated) Engineering Competency Model from [www.doleta.gov](http://www.doleta.gov)

## **Biographical Information**

Dr. Norbert J. Delatte, Jr., P.E., is the M.R. Lohmann Endowed Professor of Engineering and the Head of the School of Civil and Environmental Engineering at Oklahoma State University. He is the Chair of TRB Committee AFN20 Properties of Concrete and the former Chair of ACI Committee 325 Concrete Pavements and of Committee 327 Roller Compacted Concrete Pavements and of ACI S803 Faculty Network, Secretary of ACI 522 Pervious Concrete, and a member of several other ACI Committees.

Dr. Delatte is the author of *Beyond Failure: Forensic Case Studies for Civil Engineers* (ASCE Press, 2009) and *Concrete Pavement Design, Construction, and Performance, 2<sup>nd</sup> Edition* (Taylor and Francis, 2014). In addition, he is the Editor of ASCE's Journal of Performance of Constructed Facilities. Dr. Delatte is a registered professional engineer in the States of Ohio and Alabama and in the Commonwealth of Virginia.