ASCE POLICY 465
SHAPING THE FUTURE OF ENGINEERING EDUCATION

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1. BACKGROUND

In 1998, the American Society of Civil Engineering (ASCE) adopted Policy Statement 465 which stated "The American Society of Civil Engineers (ASCE) supports the concept of the master's degree or equivalent as a prerequisite for licensure and the practice of civil engineering at a professional level (ASCE, 2001)." The fundamental objective of Policy 465 was not a specification for the educational requirements for licensure but instead a recognition "that the current four-year bachelor's degree is becoming inadequate formal education preparation for the practice of civil engineering at the professional level in the 21st century (ASCE, 2001)." To better emphasize its fundamental objective, Policy 465 was revised and renamed "Academic Prerequisites for Licensure and Professional Practice" and introduced the concept of a specific body of knowledge (BOK) that needs to be attained to practice civil engineering at the professional level. The catalyst for Policy 465 and the development of a body of knowledge was the recognition that:

- Existing civil engineering curriculums do not adequately prepare engineers for a rapidly changing work environment and for leadership roles.
- There is an ongoing gradual historic reduction in credit hours required for the baccalaureate civil engineering degree.
- The education, experience, licensing, certification and continuing professional development process for civil engineers has failed to maintain status compared to other professions.
- The compensation received by civil engineers relative to other engineering disciplines and other professions is lower.
- Civil engineering is losing its appeal to highly motivated young people.

The long-term, considered in the range of 10 to 15 years, implementation of Policy 465 is guided by the Committee on Academic Prerequisites for Professional Practice (CAP^3), formerly called the Task Committee on Academic Prerequisites for Professional Practice (TCAP^3). Within the CAP^3, a curricula committee, licensure committee, an accreditation committee, and a fulfillment and validation committee were initiated to work on parallel fronts to promote implementation of Policy 465. The accreditation committee was tasked to draft civil engineering program criteria that would incorporate the BOK into Accreditation Board for Engineering and Technology (ABET) undergraduate civil engineering criteria. In addition, the committee is developing proposed modifications to the advanced level general criteria to assure that graduates of a master's program in civil engineering have fulfilled the complete educational component of the civil engineering body of knowledge. The licensure committee is working with the National Council of Examiners for Engineering and Surveying (NCEES) Licensure Qualification Oversight Group to examine the possibility of incorporating into the NCEES Model Law additional engineering education beyond the bachelor's degree as a prerequisite for licensure. Because changes to the Model Law would pertain to all engineering disciplines, it will be important to have the other engineering disciplines support the increased educational requirements of ASCE Policy 465. The fulfillment and validation committee is tasked to recommend methods to validate the fulfillment of the BOK attained through various educational delivery modes (distance education, corporate universities, public agency courses, and professional society offerings) and to determine how to describe, measure, and assess the quality of the education that is compliant with Policy 465. The curricula committee was tasked to define what should be taught to and learned by future civil engineering students. The work of this committee yielded the body of knowledge (BOK) that defines the knowledge, skills, and attitudes necessary for professional licensure.

2. THE ASCE BODY OF KNOWLEDGE

The ASCE BOK is composed of 15 outcomes, Table 1, and their associated levels of achievement. The outcomes include 11 outcomes used by ABET and 4 additional outcomes that add technical depth and professional practice breadth. Initially, three levels of competency, recognition, understanding or ability, were assigned to each outcome. For any one outcome, the levels of competency were to be achieved at various stages of a professionals career – formal baccalaureate education, post-baccalaureate education (master's / +30), pre-licensure experience, or post-licensure experience and education.

Initial attempts to evaluate existing civil engineering curriculum using the BOK highlighted a flaw in the levels of competency. Lacking understandable and readily applicable competency definitions, even committee members were unable to consistently apply the competency levels to their own curricula. Therefore, the levels of competency were reevaluated and the three levels of competency were replaced with five levels of achievement based on Bloom's taxonomy. Bloom divided the cognitive domain, considered to be knowledge and development of intellectual skills, into six levels of development: knowledge, comprehension, application, analysis, synthesis, and evaluation. These levels were adopted as the levels of achievement for the BOK, Table 2. The advantage of basing the levels of achievement of Bloom's taxonomy is that they are widely known and understood across the education community. A group of action-oriented verbs can be associated with each achievement level making evaluation of curriculum more consistent. With the addition of the levels of achievement based on Bloom's taxonomy (Bloom, 1956) and a listing of action verbs related to each level of achievement, a BOK outcome rubric was established to further aid in evaluating and establishing curriculum ASCE (2005).

The BOK, graphically depicted in Figure 1, consists of the 15 outcomes described in Table 1 and six levels of achievement described in Table 2. For each of the 15 BOK outcomes the specified levels of achievement are obtained either in a baccalaureate program, a master's or +30 hours of post-baccalaureate education, or experience.

Table 1: <u>The 15 outcomes of the civil engineering body of knowledge</u>

	Outcome Description
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

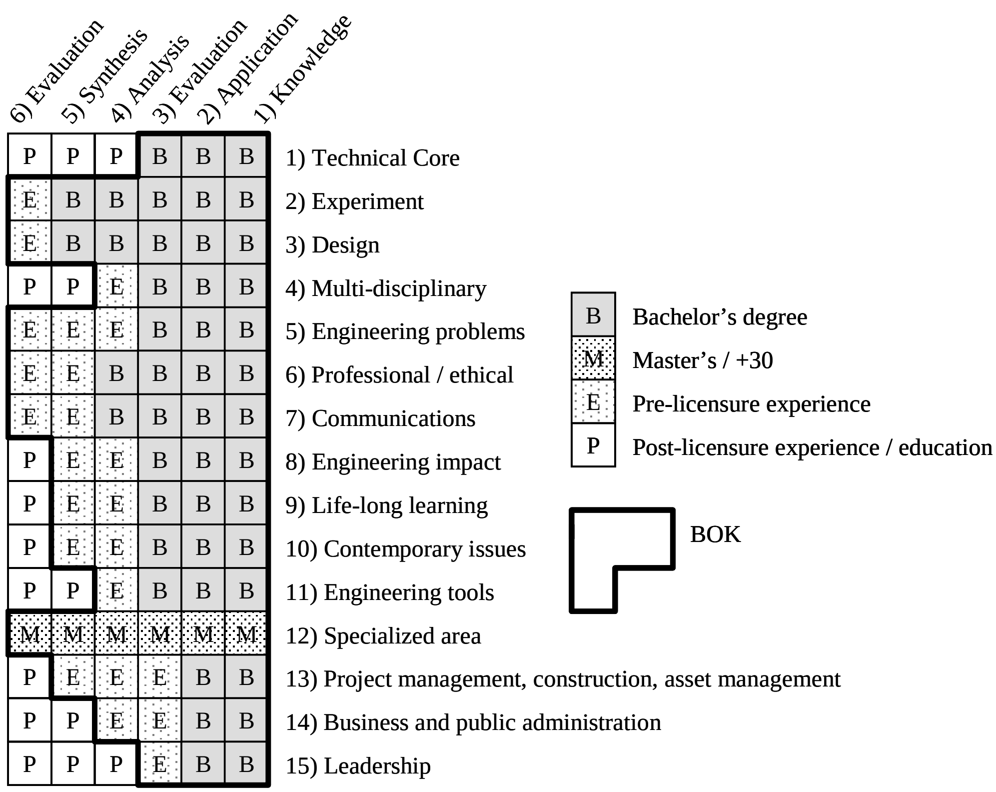

Figure 1: Graphical representation of body of knowledge

Table 2: Bloom's Cognitive Domain Levels and related action verbs

Level	Definition (Gronlund, 1978)	Action Verbs
Evaluation	Concerned with ability to judge the value of material for a given purpose. Judgments are to be based on definite criteria.	appraise; compare and contrast; conclude; criticize; critique; decide; defend; evaluate; justify
Synthesis	Refers to ability to put parts together to form a new whole.	adapt; anticipate; collaborate; compile; design; develop
Analysis	Refers to ability to break down material into its component parts so its organizational structure may be understood.	analyze; correlate; distinguish; formulate; infer; prioritize
Application	Refers to ability to use learned material in new and concrete situations.	administer; apply; calculate; demonstrate; prepare
Comprehension	Defined as the ability to grasp the meaning of material.	classify; cite; convert; describe; discuss; explain
Knowledge	Defined as remembering of previously learned material.	define; describe; enumerate; identify; reproduce; select

3. IMPACT OF BOK ON EXISTING CIVIL ENGINEERING PROGRAMS

3.1 Curriculum Evaluation – An Opportunity for Change

Full realization of Policy 465 will require civil engineering curricula to attain the BOK outcomes at the prescribed achievement level. This will require faculty to evaluate at both the program and course level their curriculum in comparison to the BOK. Although the first 11 BOK outcomes align with the ABET's (a) through (k) program criteria, faculty will need to determine if their curriculum attain the specified achievement level for these outcomes. BOK outcomes 13 through 15 are new outcomes that may not be adequately addressed within many curriculum. Outcome 12, ability to apply knowledge in a specialized area, is not applicable to undergraduate programs as it is assigned to fall under the post-baccalaureate education component of the BOK. However, some programs may find that they will achieve coverage of outcome 12 to a lower achievement in certain courses, specifically advanced technical courses, although most curriculums will not be able to reach level 6, evaluation.

A process to evaluate a curriculum to determine the achievement levels is an important aspect of curriculum evaluation. Civil engineering departments participating in the curriculum committee were asked to evaluate their curriculum against the BOK. No guidance was provided as to how the evaluation should be performed except for the general format of the results. Curriculum were rated at the course level with an achievement level assigned to each outcomes covered in the course. The completed evaluation matrix had individual courses listed in term order down the right-side of the chart and BOK outcomes listed across the top, Figure 2. Achievement levels were placed in the appropriate cells. An outcome not covered in the course was left blank. At the bottom of the matrix each outcome received a value indicative of the cumulative scores from the individual courses. This score was compared to the desired achievement level in the BOK.

Course Number	Course Description	Lec Hrs	Lab Hrs	Credit Hours	1. Mathematics Science & Engineering	2. Experiments, Analyze, and Interpret	3. Ability to Design a System	4. Multi-Disciplinary Teams	5. Solve Engineering Problems	6. Professional & Ethical Responsibility	7. Communicate	8. Impact of Engineering Solutions	9. Lifelong Learning	10. Knowledge of Contemporary Issues	11. Modern Engineering Tools	12. Knowledge in a Specialized Area	13. Elements of Project Management	14. Business and Public Policy	15. Leadership and Role of the Leader
Freshman																			
Fall (16 hrs)																			
RH131	Fr Comp.	40		4							3								
PH111	Phys I	40		4	3	3		1											
MA111	Calc I	50		5	3										3				
CLSK100	Col. & Lif. Skls	10		1						1	1								1
EM104	Graph. Comm.	20		2					1		3				3				
Winter (17 hrs)																			
RH	Rhet & Exp. Course	40		4							3								
PH112	Phys II	40		4	3	3		1											
MA112	Calc II	50		5	3										3				
CE110	Intro CE Comp. Ap.	40		4	2	1					2				3	1			
Spring (17 hrs)																			
Sci	Science Elective	40		4	3														
MA113	Calc. III	50		5	3										3				
EM103	Intro to Design	10	20	2			2	4		2	4								3
EM120	Eng. Statics	40		4	4														
CE101	Eng. Surv. I	0	60	2	4	4	3	3	2	2	4	2	2	2	3	2	2	1	3
Sophomore																			
Fall (18 hrs)																			
GL	Global Studies Course	40		4														1	
CHEM201	Engrg Chem I	40		4	3	3		1											
MA221	Diff Eq I	40		4	3														
EM202	Dyn	40		4	4				3										
CE201	Eng. Surv II	0	60	2	4	4	4	5	3	3	4	2	3	3	4	4	3	2	4
Winter (16 hrs)																			
GL	Global Studies Course	40		4														1	
CHEM202	Engrg Chem II	40		4	3	3		1											
MA222	Dif Eq II	40		4	3														
EM203	Mech. of Matls	40		4	3	2	4								3				
Spring (14 hrs)																			
MA223	Stat. for Engrs	40		4															
EM301	Fluid Mx.	40		4	3		2		3										
CE320	Matl Sci.	30	30	4	4	5	4	4	4	3	4	3	3	3	4	4	3	2	4
CE310	Comp Ap. I	20		2	3				3						3				
Junior																			
Fall (16 hrs)																			
CHE201 or	Cons Prin or Elem EE	40		4															
CE371	Hyd. Eng.	30	30	4		4	4		1						4	3			
CE321	Structural Mech. I	40		4	4		2		4						4	3			
CE336	Soil Mech.	30	30	4	4	5	4		3		3				4	3			
Winter (17 hrs)																			
CHE202 or	Ch Proc or Therm	40		4	4				3					3					
CE471	Watr Res. Eng.	40		4			4					2			4	3			
CE432	Concrete Des. I	30		3	3		4								4	3			
CE441	Const Eng	20		2	4	4	4	4	4	4	4	4	3	4	4	4	5	3	4
Sci	Science Elective	40		4	3														
Spring (15 hrs)																			
RH330	Tech Com	40		4							4	1		1					
CE431	Steel Des	30		3	4		4	4	4						4	4			3
CE311	Comp Ap II	20		2	4				4						4				
CE461	Env. Eng. Lab		30	2		4										3			
CE460	Env. Eng.	40		4	3		4		3					2		3			
Senior																			
Fall (18 hrs)																			
VA	Values & Contemp. Issu	40		4														1	
SL	Self & Society Course	40		4														1	
CE450	Bldg Systems	40		4			3			3		2	2	2				2	1
CE489	CE Design (F)	20		2															
Tech	Tech Elec	40		4	4		4		4						4	4			
Winter (16 hrs)																			
CE303	Eng. Econ	40		4	4	4	4	5	5	4	4	5	4	4	4	4	5	5	4
CE	CE Elec	40		4															
CE489	CE Design (W)	40		4															
Tech	Tech Elec	40		4	4		4		4						4	4			
Spring (14 hrs)																			
VA	Values & Contemp. Issu	40		4														1	
SL	Self & Society Course	40		4														1	
CE400	Career Prep.	10		0								1		1			1	1	1
CE489	CE Design (S)	10		2		4	6	4	6	3	5	6	4	3	4	4	3	1	3
Tech	Tech Elec	40		4	4		4		4						4	4			

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Program Score	3	4	4	3	3	3	3	3	3	3	4	3	3	2	3
BOK	3	5	5	3	3	4	4	3	3	3	3	0	2	2	2

Figure 2: Typical program evaluation matrix

The matrix provides a detailed course-level view of BOK outcomes and proficiency levels in a curriculum and is an excellent tool for curriculum planning. In determining how best achieve a curriculum that meets the BOK, civil engineering programs have the opportunity to design a curriculum that prepares civil engineers to be the technological leaders of the next generation.

Significant educational reform will be required if civil engineers are to compete in a changing, competitive global marketplace (Russell *et al*, 2000). Civil engineering educators will be challenged to maintain and advance the technical skills of their students while increasing their professional, communication, managerial, and entrepreneurial skills. The emergence of a BOK provides an opportunity to challenge faculty to examine their entire curriculum with regards to the broader goals of the BOK. However, if programs tweak courses to provide the necessary content to achieve the BOK significant changes are unlikely. Incremental changes in today's civil engineering curriculum may not be sufficient to prepare the future civil engineer – an opportunity lost.

3.2 Additional Breadth – Integrating Humanities into the Engineering Curriculum

Increased breadth of the civil engineering curriculum outside the traditional technical areas is achieved in BOK outcomes 13 through 15. Although the achievement level of these outcomes is at level 2, the lowest of any outcome excluding outcome 12, they may be the most challenging for civil engineering programs to achieve. The movement to reduce credit hours requirements has been felt within civil engineering leading to having to do more with less. In a study of leading civil engineering programs, Russell *et al.* (2000) concluded that "not only has the number of credits comprising a BSCE degree gradually but significantly decreased, but the total credit hours of engineering content has significantly decreased in many of the nation's leading CE programs." Ironically, the professional, managerial, and entrepreneurial skills of outcomes 13, 14, and 15 as well as other "soft" skills contained in other outcomes may be the skills most necessary for the future civil engineers to assume roles of significant leadership and management.

Humanities and social sciences courses, now more broadly referred to as general education courses, constitute 21 percent of the typical civil engineering curriculum (Russell and Stouffer, 2005). General education courses provide the broad, holistic education that prepares students for a rewarding engagement in their personal and professional life and an active involvement in their civic duties. General education courses are frequently not integrated into the engineering curriculum. Students frequently end up with a collection stand alone courses that fail to focus on a central theme or demonstrate relevance to engineering. Some will argue that it is good, and perhaps necessary, to allow students to pursue personal interests and curiosities. However, 21 percent of a curriculum provides significant opportunities to cover the additional breadth and "soft" skills of the BOK.

Some general education courses such as English composition can be directly mapped to an outcome within the BOK. However, many courses may not directly map to a BOK outcome. The participating civil engineering departments within the curriculum committee frequently omitted general education elective courses from their program evaluation matrices. Humanity and social science courses provide an opportunity to integrate the "soft skills" into an engineering context. Engineering faculty will need to work with their colleagues in the humanities to develop courses that provide the broad, holistic education traditionally provided by the humanities but also place engineering in a wider cultural context. Currently, this integration of engineering and humanities is not commonly encountered.

4. BROADER IMPACT ON ENGINEERING EDUCATION

ASCE Policy 465 begins the long-term process of defining the body of knowledge essential to the professional practice of civil engineering and of shaping the role civil engineers have in the future. The challenges facing civil engineering as well as the role increased educational requirements, including the master's degree as civil engineering's first professional degree, may have in addressing these challenges have been widely discussed and debated in the literature the last several years (Russell *et al*. 2000; Nowatzki, 2004; Arciszewski, 2006). Within the civil engineering community there is not a consensus on the value of the master's degree as the first professional degree. ASCE has committed significant resources to bringing about the goal of Policy 465 – to increase the educational requirements for professional licensure and to raise the bar for the profession. However, fulfillment of Policy 465 will require ASCE to partner with universities, state licensing boards, other professional societies, and the accreditation board.

Many of the challenges addressed by the BOK are not unique to civil engineering; nor should the response be. Engineering as a profession is not viewed as of equal status to the professions of law and medicine. Both law and medicine require its students to complete a four-year undergraduate education prior to entering medical and law schools. The BOK is a step towards a parallel view of engineering education by stating that the four-year baccalaureate degree is no longer sufficient for the professional practice of civil engineering.

To fulfill the formal education component of the BOK requires a bachelor's degree plus either a master's degree or 30 credit hours of post-baccalaureate education, Figure 1. The BOK adds two technical outcomes (specialized technical area; project management, construction, and asset management) and two professional practice outcomes (business and public policy and administration; and leadership) to the eleven ABET outcomes. Only the specialized technical area outcome, outcome 12, occurs outside the undergraduate program. In the original statement of the BOK no distinction made between the baccalaureate and post-baccalaureate areas of the formal education component of the BOK. When civil engineering departments participating in the curriculum committee began to examine the BOK with respect to their individual curriculum it became apparent that outcome 12 should be assigned to post-baccalaureate education.

Full implementation of Policy 465 and the BOK will impact the traditional model of engineering education – decoupled undergraduate and graduate degree programs. Future engineering students may expect a seamless educational experience that culminates with a BOK compliant degree (either a master's degree or a bachelor's degree with an additional 30 credit hours). Research universities, the traditional producers of master's degrees, are shifting the emphasis of graduate education towards doctoral degrees. Combined five-year BS/MS engineering programs provide a seamless mode of graduate education but are few in number. Predominantly undergraduate institutions may lack the resources to provide post-baccalaureate education. Graduate distance education programs offer flexibility but also are few in number. Universities must begin to develop a strategy on how to best meet the educational expectations of the next generation of civil engineering students.

Will anyone follow ASCE's lead? Agreement with other professional societies is essential to achieving the BOK and Policy 465. Although professional licensure is more important to the civil engineering discipline, it is hard to imagine ASCE succeeding without parallel efforts undertaken in the other engineering disciplines. For the profession, ASCE's lead in raising the bar will positively improve civil engineering education and engineering education in general.

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