2006-792: SATISFYING FUTURE BODY OF KNOWLEDGE OUTCOMES

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Body of Knowledge (BOK) Outcomes in an ABET Curriculum

Abstract

The American Society of Civil Engineers (ASCE) has adopted Policy Statement 465 in recognition of the increasing complexity of civil engineering practice and the general tendency for schools to reduce the credit hours required for graduation.

The Body Of Knowledge (BOK) required to support the policy statement was also discussed. The BOK recommendations include 15 outcomes which are designed to broaden and deepen the 11 current outcomes required by the Accreditation Board for Engineering and Technology (ABET). This paper presents data that indicate civil engineering programs at the bachelor's level may presently be satisfying, to some degree, 14 of the 15 BOK outcomes. These include the 11 ABET outcomes in addition to the following:

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.

It is hoped that the knowledge gained with the BOK assists the students in their future endeavors as they become alumni practitioners.

However, outcome 12, an ability to apply knowledge in a specialized area related to civil engineering, is difficult to satisfy in a normal undergraduate civil engineering program. Nevertheless, for comparative purposes, the findings of this investigation could be utilized by other institutions and departments that may wish to study their curriculum and/or develop a system of evaluation to measure the achievement of BOK outcomes.

Introduction

In 1998 the American Society of Civil Engineers (ASCE) Board of Direction adopted Policy Statement 465 that reads, in part, as follows:[3] "ASCE supports the concept of the master's degree as the First Professional Degree (FPD) for the practice of civil engineering at the professional level." There was a great level of discussion and opposition to this approach by members of the society.[6,13,14] The perception was that outstanding practical experience may be just as or more important than advanced course work.

Upon reflection and after numerous discussions, Policy Statement 465 was amended in 2001 and 2004 and today reads: "the ASCE supports the attainment of a Body of Knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure".[2] In order to support Policy Statement 465, ASCE developed the body of knowledge (BOK) needed to enter the profession in the 21st century. Specifically, the BOK is defined as the knowledge, skills, and attitudes required to become a licensed professional engineer.

Some practitioners believe that graduates of engineering programs need greater knowledge of the design process, and increased understanding of business and management. For example, the National Research Council (NRC) has published a report concerning the following problems with students who hold the bachelors degree:[5]

- Lack of knowledge of the design process,
- Inadequate knowledge of the role of technology, and
- Minimum knowledge of business, economics, and management.

The Accreditation Board for Engineering and Technology (ABET) is also concerned with the particular knowledge and skills that the graduate of 2020 will need to enter professional practice. Meetings are being held to predict what must be included in the BOK required for future engineers.[1] It is hoped that the application of ASCE Policy Statement 465 will assist in solving the perceived problems in engineering education.

Engineering Education

Recently, there have been recommendations from educators and technical/professional societies such as ASCE and NRC, as indicated in the previous sections, to revise the engineering curriculum that is being required in accredited institutions.[6,13,14] Partially in response to these recommendations and the recognition that the traditional program must include more information, the Accreditation Board for Engineering and Technology (ABET) has revised the criteria for accrediting engineering programs[4]. To assist in implementing the revised criteria, numerous conferences have been held and papers published involving the topics of accreditation and the curriculum.

For example, this is the fifth paper in a series published by the principal author designed to study the engineering curriculum and accreditation criteria. In the first publication, respondents were requested to indicate whether credit hours allocated to various courses should be revised.[8] The findings based upon 93 returns show, in part, that (1) practitioners recommend an increase in credits in the English literature and composition, especially technical writing, areas; (2) older graduates recommend greater academic emphasis in law, accounting, construction estimating and specifications, oral communications, and personnel management.

The second paper was designed to investigate the recommendations included in the updated Engineering Criteria. Specifically, knowledge of professional practice issues and the ability to perform engineering design utilizing realistic design constraints was studied.[9] Here, the findings based upon 68 respondents suggest, in part, that both undergraduate and graduate students as well as practitioners perceive that engineering codes/standards and constructability constraints presently have been and are recommended to be incorporated into the engineering design program at a high level.

The third paper in the series, involves the perception of students and practitioners concerning the *Program Criteria for Civil and Similarly Named Engineering Programs* which is included in the ABET criteria.[4] The findings, based upon 69 usable forms, suggest that practicing

engineers as well as undergraduate and graduate students, perceive that a major design experience or course should receive a high level of coverage in the civil engineering curriculum.[10]

"Practitioner and Employer Assessment of Accreditation Board for Engineering and Technology Outcome Criteria" is the fourth paper.[11] Here, civil engineering alumni and their employers rate "The broad education necessary to understand the impact of engineering solutions in a global/societal context" at a level lower than the ten other subject areas under consideration. Overall, 178 survey forms were returned, the tabulated results of which form the database for this investigation.

The fifth paper, investigates, according to civil engineering students at Lamar University, the level at which their understanding of various subject areas required by *Engineering Criteria 2000*, and specifically listed in the *Program Criteria for Civil and Similarly Named Engineering Programs* and the *General Criteria* (Professional Component) may have been enhanced by being involved with the steel bridge and concrete canoe projects.[12] The following were determined to be greatly enhanced: project management/scheduling and estimating, team work, and constructability. The study covered a two year period and the findings were based on the 46 usable questionnaires returned during the investigation.

Overall it appears that the foregoing five papers support the present educational concerns of the NRC, ABET and ASCE. In addition, the full papers present, in part, the concept that the traditional four year engineering degree is no longer enough to practice as a professional engineer.

Body of Knowledge (BOK)

In order to determine the BOK required for civil engineers, ASCE proposes to utilize outcomes that are nominally similar to the eleven (a-k) Accreditation Board for Engineering and Technology (ABET) outcomes in addition to the specific program criteria required for civil engineering students. In order to totally satisfy BOK specifications, a single depth outcome, and three breadth outcomes were also added to the basic ABET requirements. The depth outcome includes knowledge in a specialized technical area. The three breadth outcomes include project management, construction, and asset management; business and public policy, and administration; and leadership.[3]

Specifically, according to BOK criteria, the 21st century civil engineer must demonstrate the following:[3]

1. An ability to apply knowledge of mathematics, science, and engineering. (ABET a)
2. An ability to design and conduct experiments, as well as analyze and interpret data. (ABET b)
3. An ability to design a system, component, or process to meet desired needs. (ABET c)
4. An ability to function on multi-disciplinary teams. (ABET d)
5. An ability to identify, formulate and solve engineering problems. (ABET e)
6. An understanding of professional and ethical responsibility. (ABET f)

7. An ability to communicate effectively. (ABET g)
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context. (ABET h)
9. A recognition of the need for, and an ability to engage in, life-long learning. (ABET i)
10. A knowledge of contemporary issues. (ABET j)
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (ABET k)
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 above, a BOK committee recommends three levels of competence which should be considered for engineers who intend to become licensed professionals.[20] They include the following:

- Level 1 (Recognition) represents a reasonable level of familiarity with a concept.
- Level 2 (Understanding) implies a thorough mental grasp and comprehension of a concept or topic.
- Level 3 (Ability) is a capability to perform with competence.

The committee also recommends to refine the 11 ABET outcomes previously listed. They are still somewhat similar; however, active verbs are utilized to describe the expected level of achievement.

Perceptions of Required ABET Outcomes

In order to satisfy ABET requirements, a survey instrument was distributed to alumni practitioners, employers, and graduating seniors of the Civil Engineering Department at Lamar University. The questionnaire listed the eleven required educational outcomes (a)-(k) and requested that respondents indicate at which level – strongly agree, agree, neither disagree, nor agree, disagree or strongly disagree – each outcome has been incorporated into the curriculum.[11] As shown in Table 1, BOK requirements 1-11 are well satisfied.

In particular, Table 1 lists data from the various constituencies of the civil engineering program.[11] As shown, the composite scores of graduating students indicate that two outcomes are covered at one of highest levels (4.6), including:

- An ability to apply knowledge of mathematics, science, and engineering; and
- An ability to identify, formulate, and solve engineering problems.

Table 1. Practitioner and Employer Assessment[11] (178 respondenents)

Fulfillment of the 11 Outcomes specified by ABET , as a Composite Score*			
Educational Outcome (1)	Graduating Seniors (2)	Alumni Practitioners (3)	Employers (4)
An ability to apply knowledge of mathematics, science, and engineering	4.6	4.5	4.2
An ability to design and conduct experiments, as well as to analyze and interpret data	4.5	4.3	4.2
An ability to design a system, component, or process to meet desired needs	4.4	4.1	4.2
An ability to function on multidisciplinary teams	4.4	4.1	4.4
An ability to identify, formulate and solve engineering problems	4.6	4.4	4.3
An understanding of professional and ethical responsibility	4.6	4.3	4.4
An ability to communicate effectively	4.7	4.1	4.1
The broad education necessary to understand the impact of engineering solutions in a global/societal context	4.4	3.9	3.8
A recognition of the need for an ability to engage in lifelong learning	4.7	4.2	4.2
A knowledge of contemporary issues	4.4	4.1	4.2
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	4.4	4.1	4.2

* Composite score based upon 5.0= strongly agree; 4.0=agree; 3.0=neither agree nor disagree;2.0=disagree; 1.0=strongly disagree

In addition, alumni practitioners perceive that the program has given them an above average background in these areas (4.5, 4.4). These results indicate strong support for the application of the technical aspects of engineering. This may be considered to be the traditional role of civil/construction engineers.

The four attributes or outcomes listed below and shown in Table 1 are also rated with relatively high scores (4.4-4.7) by graduating seniors of Lamar University

- A knowledge of contemporary issues;
- An understanding of professional and ethical responsibility;
- An ability to communicate effectively; and
- The broad education necessary to understand the impact of engineering solutions in a global and societal context.

These findings suggest that in addition to the traditional technical aspects of civil/construction engineering, students and alumni practitioners believe they have received a good background in the professional aspects of civil engineering and satisfy BOK requirements 1-11.

Table 1 also illustrates that there may be large differences in composite scores. For example, graduating seniors at Lamar University indicate that they strongly recognize the need for an ability to engage in lifelong learning (4.7) as well as an ability to communicate effectively (4.7). In contrast, practitioners do not believe they received the same background in these areas when they were in school (4.2, 4.1). However, the perceptions of practitioners most likely reflect, in part, the actual job experiences of the practicing engineers responding to the questionnaire.

Perceptions of BOK Outcomes

The data in Table 2 is obtained from an investigation concerning the Department of Civil Engineering at Lamar University that was published in 2001.[10] As illustrated, the information shown in the brackets support BOK 13 (an understanding of the elements of project management, construction and asset management, in addition to that of BOK 14, and 15. Specifically the composite scores are in the average to above average range varying between 2.9 – 3.6.

Table 3 presents information that also supports the outcomes required in BOK. Here, civil engineering seniors of and alumni practitioners from the Civil Engineering Department of Lamar University indicate, as shown in the bracket, average support (2.8/3.4) of legal factors, health and safety issues, and ethical considerations. These items are strongly related to BOK 14, an understanding of business and public policy and administration fundamentals. In addition, the scores for BOK 13 and 14 vary between 2.9 – 3.6.

The data in Table 4 is extracted, in part, from a paper accepted for publication by the American Society of Civil Engineers.[12] As indicated in the bracket, BOK outcome 15; an understanding of the role of the leader and leadership principles and attitude, was supported by the concept of team work (3.6). Here, the composite scores were based on the perceptions of

Table 2. ABET Program Criteria [10] (69 respondents)

Fulfillment of new outcomes specified by the BOK Committee, as a Composite Score*		
Educational Outcome (1)	Graduating Seniors (Current Coverage) (2)	Alumni Practitioners (Recommended Coverage) (3)
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 [Construction Management][10]	3.1	3.6
14.) An understanding of business and public policy and administration fundamentals [Procurement of work; bidding as quality based selection][10]	2.9	3.3
15.) An understanding of the role of the leader and leadership principles and attitudes [Interaction of design and construction professionals][10]	2.9	3.2

* Composite score based upon 4.0= High; 3.0=Average; 2.0=Low; 1.0=Unsure.

Table 3. Preparing Students [9] (68 respondents)

Fulfillment of new outcomes specified by the BOK Committee, as a Composite Score*		
Educational Outcome (1)	Graduating Seniors (Current Coverage) (2)	Alumni Practitioners (Recommend-ed Coverage) (3)
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 [Constructability; Engineering codes and standards] [9]	3.2	3.6
14.) An understanding of business and public policy and administration fundamentals [Legal factors; health and safety issues; ethical considerations] [9]	2.8	3.4
15.) An understanding of the role of the leader and leadership principles and attitudes [Economic factors] [9]	2.9	3.3

* Composite score based upon 4.0= High; 3.0=Average; 2.0=Low; 1.0=Unsure.

Table 4. Engineering Experience and Competition [12] (46 respondents)

Fulfillment of new outcomes specified by the BOK Committee, as a Composite Score*		
Educational Outcome (1)	Graduating Seniors (Current Coverage) (2)	Alumni Practitioners (Recommend-ed Coverage) (3)
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 [Project Management, scheduling and estimating] [12]	3.7	---
14.) An understanding of business and public policy and administration fundamentals [Legal factors; health and safety issues; ethical considerations] [12]	3.1	---
15.) An understanding of the role of the leader and leadership principles and attitudes [Team work] [12]	3.6	---

* Composite score based upon 4.0= High; 3.0=Average; 2.0=Low; 1.0=Unsure.

students involved with the steel bridge and/or concrete canoe projects or practical experience. BOK outcomes 13 and 14 were also supported with scores 3.7, 3.1.[12]

In review, the data in Tables 1 – 4, obtained from various investigations conducted over a number of years, indicate that undergraduate students in a civil engineering program ordinarily believe they satisfy, in their program of study, BOK outcomes 1 – 11 and 13 – 15.

Education Requirements for Certified Public Accountants

As in civil engineering, the educational component to the BOK required for accountants recently joining the profession is tending to increase. Nevertheless, for both new and older practitioners, being designated as a Certified Public Accountant is the most prestigious credential an accountant can achieve. However, for an individual to become a Certified Public Accountant, a candidate must comply, as in engineering, with the requirements of the state in which the individual wishes to practice. The general components of the initial licensing requirement include passing the Uniform CPA Exam, work experience and educational requirements. Each state specifies the education requirements of a certain number of accounting hours and other business credits. In addition, candidates are required (or shortly will be required) by 45 states to have completed 150 semester hours of coursework.[16] As part of the 150 hours, a candidate must have earned either a bachelor's or a master's degree.[18] There is no requirement for a master degree and the entire 150 hours can be composed of undergraduate coursework.[18] Previously only a bachelor's degree with certain specific coursework was the requirement. The idea of additional education was endorsed by the American Institute of Certified Public Accountants governing council in 1959 and approved by the general membership in 1988, nearly 30 years later.[17] The recommended implementation date was set for sometime after the year 2000. This time span required to change educational requirements is similar to that in civil engineering.

Over approximately the last fifteen years, the number of accounting graduates has declined as well as the number of candidates sitting for the CPA exam.[19] During the 1990-91 academic year the total number of accounting graduates (both undergraduate and master's degree) was 59,140. This total declined to 46,555 for the year 2000-01 academic year and recovered somewhat by the 2003-04 academic year to 53,760.[19] The recent uptick in graduates is attributed to the increase in exposure to and interest in accounting due to business scandals such as the failure of Enron and Worldcom. Over the same time period, the composition of the accounting graduates has shifted from being about 9% master's degree graduates in 1990-91 to 19% in 2000-01 and 25% in 2003-04.[19] The increase in the relative position of master's level graduates is attributed to the 150 hour requirement. However, over the same fifteen year period, the number of candidates sitting for the CPA exam has dropped from 143,572 in 1990 to 115,493 in 2000 and to 109,872 in 2003.[19] It will be interesting to see if civil engineering experiences similar change, increase in master's degrees and decrease in numbers sitting for the professional practice exam, over the next twenty years.

Summary and Conclusion

For the 21st century civil engineer, broad and/or specific knowledge in numerous areas will be necessary to practice as a professional engineer. To gain this knowledge it is recommended that he/she will need a master's degree or equivalent practical experience. ASCE developed a set of criteria called BOK, for future engineers to satisfy to become licensed professional engineers. The BOK consists of the existing 11 ABET outcomes, plus four new additional criteria. This investigation indicates that almost all the BOK outcomes tend to be perceived by the respondents as being satisfied in the currently existing undergraduate curriculums, except one, specialized knowledge. Obtaining knowledge in a specialized area is found to be difficult to accomplish in an undergraduate program.

The findings of the paper have been obtained by using data collected from various studies published in different journals. In particular; feedback from students and alumni practitioners was utilized. The results which are presented in Tables 1-4, indicate that the present curriculum tends to satisfy, as perceived by the respondents, most BOK criteria. Again, BOK Twelve, an ability to apply knowledge in a specialized area related to construction/civil engineering, could possibly be satisfied with a master's degree or acceptable practical experience.

Bibliography

1.) ABET 2020. (2003). Accreditation Board for Engineering and Technology. Baltimore, MD, www.abet.org.

2.) ASCE Policy Statement 465. (2004). ASCE, Reston, Virginia, www.asce.org.

3.) Civil Engineering Body of Knowledge for the 21st Century. (2004). ASCE, Reston, Virginia, www.asce.org.

4.) Criteria for Accrediting Engineering Programs. (2004). Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), Baltimore, MD, http://www.abet.org.

5.) Engineering Education and Practice in the United States: Engineering Undergraduate Education. (1986). National Academy Press, Washington, DC.

6.) Hampton, D. (2000). "More Education is needed for Civil Engineers." ASCE News, ASCE, 25(1), 6.

7.) Henry, W.P. (2005). " Broadening the Education Base." ASCE News, ASCE, 30(4), 4.

8.) Koehn, E. (1995). "Practitioner and Student Recommendations for an Engineering Curriculum." *Journal of Engineering Education*, ASEE, 84(3), 241-248.

9.) Koehn, E.(1999). "Preparing Students for Engineering Design and Practice," *Journal of Engineering Education*, ASEE, 88(2), 163-168.

10.) Koehn, E. (2001). "ABET Program Criteria: Review and Assessment for a Civil Engineering Program." *Journal of Engineering Education*, ASEE, 90(3), 445-455.

11.) Koehn, E. and Parthasarathy, M.S. (2005). "Practitioner and Employer Assessment of Accreditation Board for Engineering and Technology." *Journal of Professional Issues in Engineering Education and Practice*, ASCE, 131(4), 231-237.

12.) Koehn, E. (2006). "Engineering Experience and Competitions Implement ABET Criteria." *Journal of Professional Issues in Engineering Education and Practice*, ASCE, 132(2), 1-7.

13.) Russell, J.S., Stonffer, B., and Walesh, S.G. (2000). " The first Professional Degree: A Historic Opportunity." *Journal of Professional Issues in Engineering Education and Practice*, ASCE, 126(2), 54-63.

14.) Walesh, S.G.(2000). "Engineering a new Education." *Journal of Management in Engineering,* ASCE, 35-40.

15.) Work Product of the Accreditation Committee of CAP^3. (2005). "Proposed Changes to the Criteria for Accrediting Engineering Program." ASCE, Reston, Virginia.

16.) American Institute of Certified Public Accountants (AICPA). (2002). *States That Have Passed the 150-Hour Education Requirement.* http://www.aicpa.org/states/uaa/150chart.htm.

17.) American Institute of Certified Public Accountants (AICPA). (2005). *Background Information on the 150-Hour Education Requirement for CPA Certification and Licensure*. http://www.aicpa.org/nolimits/become/150hr/150her/150bkg.htm

18.) American Institute of Certified Public Accountants (AICPA). (2005). *AICPA/NASBA Guide Implementing the 150-Hour Requirement*. http://aicpa.org/states/uaa/150hour.htm.

19.) Sanders, Beatrice. (2005). *The Supply of Accounting Graduates and the Demand for Public Accounting Recruits-2005*: For the Academic Year 2003-2004. New York: American Institute of Certified Public Accountants.

20.) Report of the Levels of Acheivement Subcommitte to the ASCE Committee on Academic Prerequisites for Professional Practice. (2005). ASCE, Reston, Virgina, www.asce.org