ABET Educational Assessment: Outcomes (a)-(k)

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Abstract

The Accreditation Board for Engineering and Technology (ABET) has revised the accreditation criteria that is designed to assure that graduates of accredited programs are prepared to enter the practice of engineering and satisfy industrial requirements. The general criteria also specifies that engineering programs must demonstrate that their graduates possess or satisfy eleven (11) educational attributes or outcomes generally known as "a" through "k".

This investigation suggests that both industrial practitioners and undergraduate Civil (Construction) Engineering students consider two of the eleven (11) outcomes to be particularly important. In addition, graduating seniors in Civil (Construction) engineering believe their coursework has given them a strong background in the identical two areas. These include: (1) an ability to apply knowledge of mathematics, science, and engineering; and (2) an ability to identify, formulate, and solve engineering problems. In contrast, three outcomes received slightly lower ratings from each of the groups. These include, a knowledge of contemporary issues; the broad education necessary to understand the impact of engineering solutions in a global/societal context; and an ability to design a system, component, or process to meet desired needs. Overall, the data may suggest that not all ABET educational attributes are considered by graduating seniors in Civil (Construction) engineering, industrial practitioners, and undergraduates to have the same level of significance and perhaps should not be stressed to the same degree in an engineering program. For comparative purposes, the findings of the investigation could be utilized by other institutions and departments that may wish to study and/or assess their curriculum and satisfy ABET criteria.

I. Introduction

Over the years there have been recommendations from employers and various technical/professional societies to revise the engineering curriculum to ensure that students are prepared for the increasing complexity and international aspects of engineering work[3, 4, 12, 15]. Engineering educators have also been involved with these efforts[5, 7, 8, 9]. Nevertheless, there appears to be a general belief that the engineering profession must change so that in the future it will be highly recognized and respected at national and international levels[1, 2, 14].

This paper presents the results of an investigation of the perceptions of three groups: graduating seniors, engineering undergraduates, and practitioners. The data for the study was obtained, in part, from a survey instrument that was distributed to graduating seniors and civil engineering undergraduates at Lamar University. In addition, a similar questionnaire was completed by practicing engineers who attended an alumni meeting sponsored by the civil engineering department. Practitioners were requested to indicate the optimal level at which the various attributes should be incorporated into the curriculum. Graduating seniors and undergraduates were asked to indicate the level at which their civil engineering coursework was related to the 11 attributes or outcomes, “a” through “k”.

II. *Engineering Criteria*

ABET, the recognized accreditor for college and university programs in engineering, technology, computing, and applied science, is a federation of 31 professional and technical societies representing these fields. For 70 years, ABET has provided quality assurance of higher education through accreditation. ABET currently accredits some 2,500 engineering, technology, computing, and applied science programs at over 550 colleges and universities nationwide. Over 1,500 volunteers participate annually in ABET’s accreditation activites[13].

The guiding objective or principle of ABET Engineering accreditation is to assure that graduates of an accredited program are prepared to enter and continue the practice of engineering. In addition, the Engineering Accreditation Commission expects the Criteria to stimulate the improvement of educational outcomes and encourage new and innovative approaches to engineering education[11].

To enhance this objective, *Engineering Criteria 2000* requires that engineering programs must demonstrate that their graduates possess the following:

(a) An ability to apply knowledge of mathematics, science, and engineering
(b) An ability to design and conduct experiments, as well as to analyze and interpret data
(c) An ability to design a system, component, or process to meet desired needs
(d) An ability to function on multidisciplinary teams
(e) An ability to identify, formulate, and solve engineering problems
(f) An understanding of professional and ethical responsibility
(g) An ability to communicate effectively
(h) The broad education necessary to understand the impact of engineering solutions in a global/societal context
(i) A recognition of the need for, and an ability to, engage in lifelong learning
(j) A knowledge of contemporary issues
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

In addition, each engineering program is expected to develop a qualitative and, where applicable, a quantitative system including the development of the following[11]:

- the institution’s mission
- educational objectives, and the extent to which the needs of the program’s various

constituencies are used to determine and periodically evaluate the educational objectives

- specific outcomes and the processes to realize these outcomes and the extent to which outcomes are being assessed
- ongoing evaluation that demonstrates achievement of the educational objectives and program outcomes and uses the results to continuously improve the effectiveness of the program
- an integrated plan to meet the accreditation requirements with respect to students, the professional component, faculty, facilities, institutional support and financial resources, and program criteria

III. Perceptions of Educational Attributes or Outcomes

As a segment of the continuing review and evaluation of the curriculum, a survey instrument was distributed to alumni practitioners, undergraduates, and graduating seniors of the Civil Engineering Department of Lamar University. The tabulated results of which form the database for the investigation. The questionnaire listed 11 educational attributes or outcomes and requested that respondents indicate at which level—strongly agree/high, agree/average, disagree/low, or neither agree or disagree/unsure—each attribute should be or is incorporated into the curriculum. The educational attributes chosen were those that engineering programs must require of their students before they are allowed to graduate. They were included in the program outcomes and assessment section of *Engineering Criteria 2000* and are listed in the previous section as “a” through “k”.

In particular, Table 1 lists the recommendations of practitioners who have graduated from civil engineering programs. As shown, the composite scores indicate that two attributes should be covered at the highest level (3.9), including:

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

In addition, graduating seniors and undergraduates perceive that the program has given them an above average background in these areas. 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 2 are also rated with relatively high scores, 3.4 – 3.7.

- An ability to design and conduct experiments, as well as to analyze and interpret data
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

These findings suggest that in addition to the traditional technical aspects of civil (construction) engineering, an understanding of professional and ethical responsibility, and an ability to communicate effectively are considered vital to the profession.

Table 1. Comparison of ABET Attributes with Practitioner Scores = 3.9			
Level of Educational Attributes, as a Composite Score			
Educational Attribute (1)	Graduating Seniors (2)	Practitioners (3)	Under-Graduates (4)
An ability to apply knowledge of mathematics, science, and engineering	3.8	3.9	3.7
An ability to identify, formulate and solve engineering problems	3.7	3.9	3.5
Composite score based upon 4.0=strongly agree/high; 3.0=agree/average; 2.0=neither agree nor disagree/unsure; 1=disagree/low			

Table 2. Comparison of ABET Attributes with Relatively High Composite Scores			
Level of Educational Attributes, as a Composite Score			
Educational Attribute (1)	Graduating Seniors (2)	Practitioners (3)	Under-Graduates (4)
An ability to design and conduct experiments, as well as to analyze and interpret data	3.6	3.5	3.5
An understanding of professional and ethical responsibility	3.7	3.6	3.4
An ability to communicate effectively	3.7	3.7	3.4
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	3.6	3.7	3.5
Composite score based upon 4.0=strongly agree/high; 3.0=agree/average; 2.0=neither agree nor disagree/unsure; 1=disagree/low			

IV. Practitioner Perceptions and Recommendations

In the previous section, various attributes were listed that, according to the respondents to the survey, should be presented at a high level. Nevertheless, as shown in Table 3, three attributes—an ability to design a system, component, or process to meet desired needs; the broad education necessary to understand the impact of engineering solutions in a global/societal context; and a knowledge of contemporary issues—are rated by practitioners in the average range (3.0). This suggests that practicing civil engineers do not believe that all *Engineering Criteria 2000* attributes should be in the high level category. Nevertheless, graduating seniors have indicated relatively strong support for these attributes.

Table 4 illustrates that there may be large differences in composite scores. For example, graduating seniors indicate that they strongly recognize the need for and an ability to engage in lifelong learning as well as an ability to function on multidisciplinary teams. Practitioners do not support these attributes to the same degree. The perceptions of practitioners most likely reflect the actual job experience of the individuals responding to the questionnaire. In this regard, a number of practitioners have written comments involving specific attributes, including[10]:

- Lifelong learning in the form of documented continuing education classes or experiences will most likely be required by the various state registration boards in 10-15 years
- The ability to design a system, component, or process to meet desired needs should be developed in a work environment, and not in a classroom
- An understanding of professional and ethical responsibility is difficult to accomplish in an academic setting
- Knowledge and use of modern methods does not necessarily guarantee a quality product

Table 3. Comparison of ABET Attributes with Practitioner Scores = 3.0

Level of Educational Attributes, as a Composite Score			
Educational Attribute (1)	Graduating Seniors (2)	Practitioners (3)	Under-Graduates (4)
An ability to design a system, component, or process to meet desired needs	3.4	3.0	3.5
The broad education necessary to understand the impact of engineering solutions in a global/societal context	3.4	3.0	3.5
An knowledge of contemporary issues	3.5	3.0	3.0

Composite score based upon 4.0=strongly agree/high; 3.0=agree/average; 2.0=neither agree nor disagree/unsure; 1=disagree/low

Table 4. Comparison of ABET Attributes with Relatively Large Differences in Composite Scores			
Level of Educational Attributes, as a Composite Score			
Educational Attribute (1)	Graduating Seniors (2)	Practitioners (3)	Under-Graduates (4)
An ability to function on multidisciplinary teams	3.5	3.1	3.5
A recognition of the need for and an ability to engage in lifelong learning	3.9	3.4	3.3
Composite score based upon 4.0=strongly agree/high; 3.0=agree/average; 2.0=neither agree nor disagree/unsure; 1=disagree/low			

It is noteworthy that according to the above listing some practitioners believe that industry is in a better position than an educational institution to teach certain concepts in engineering.

V. Benchmarking Data

Tables 1-4 include data involving students enrolled at Lamar University in addition to practitioners who have graduated from the Civil (Construction) engineering program at the institution. It reflects, in part, the education and exposure to the profession that the students have received while studying for their degree.

In order to obtain a larger data base for comparison purposes, information from EBI Engineering Education e News was utilized[6]. Here, results based on approximately 7,000 responses from graduating seniors at 58 engineering schools are available. The information includes a tabulation of the highest and lowest score for various Engineering majors. These include: Aerospace, Bioengineering, Chemical, Civil/Construction, Computer/Computer Science, Electrical/Electronic, Engineering Management, Environmental, Industrial, Materials, and Mechanical/Mechanics Engineering.

Specifically, as illustrated in Table 5, the students at Lamar University rate ABET outcomes "a" through "k" with a higher score compared to those students included in the EBI benchmarking data. In particular, the following attributes are among those showing the largest difference in composite scores.

- An understanding of professional and ethical responsibility
- A recognition of the need for and an ability to engage in lifelong learning
- A knowledge of contemporary issues

Table 5. Comparison of ABET Attributes with Benchmarking Data		
Level of Educational Attributes, as a Composite Score		
Educational Attribute (1)	Graduating Seniors (2)	Benchmarking Data (3)
An ability to apply knowledge of mathematics, science, and engineering	3.8	Unavailable
An ability to design and conduct experiments, as well as to analyze and interpret data	3.4	3.2 – 2.9
An ability to design a system, component, or process to meet desired needs	3.6	3.2 – 2.9
An ability to function on multidisciplinary teams	3.5	3.3 – 2.7
An ability to identify, formulate and solve engineering problems	3.7	3.3 – 3.0
An understanding of professional and ethical responsibility	3.7	3.1 – 2.6
An ability to communicate effectively	3.7	3.2 – 2.7
The broad education necessary to understand the impact of engineering solutions in a global/societal context	3.4	3.0 – 2.5
A recognition of the need for an ability to engage in lifelong learning	3.9	3.3 – 2.9
A knowledge of contemporary issues	3.5	2.8 – 2.1
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	3.6	3.0 – 2.7
Composite score based upon 4.0=strongly agree/high; 3.0=agree/average; 2.0=neither agree nor disagree/unsure; 1=disagree/low		

Reviewing the data it appears that graduating seniors in Civil (Construction) engineering at Lamar University perceive they have obtained a much stronger background in professional issues compared to the students involved in the benchmarking study. It is hoped that this additional background information will assist the Lamar students in their future career as engineering practitioners.

VI. Summary and Conclusions

Engineering program assessment for an academic institution is periodically conducted by an ABET team during a scheduled accreditation visit. *Engineering Criteria 2000* is designed to assure that graduates of accredited programs are prepared to enter the practice of engineering.

Specifically, it is required that engineering programs must demonstrate that their graduates have satisfied 11 educational attributes or outcomes commonly known as “a” through “k”.

As part of a continuing review and evaluation of its curriculum, the Civil Engineering Department at Lamar University distributed a survey instrument to three groups: graduating seniors, undergraduates, and practitioners. The questionnaire listed the aforementioned 11 educational outcomes and asked respondents to indicate the level at which they are or should be included in the engineering curriculum. The findings indicate that the respondents believe that two of the 11 attributes have been and should be incorporated into the curriculum at a high level. They include: an ability to apply knowledge of mathematics, science, and engineering; and an ability to identify, formulate, and solve engineering problems. These results suggest strong support for the traditional technical aspect of engineering. In contrast, three attributes received slightly lower ratings. They include: the broad education necessary to understand the impact of engineering solutions in a global and societal context; a knowledge of contemporary issues; and an ability to design a system, component, or process to meet desired needs. This suggests that not all ABET educational attributes are considered by respondents to have the same level of significance, and should, perhaps, not be stressed to the same degree in an engineering curriculum.

Overall, the findings indicate that practicing engineers tend to rate some of the ABET educational outcomes at a lower level compared with undergraduate and graduating students. This may reflect a natural human resistance to change. However, the data and comments also suggest that practitioners do not believe that the attributes, in general, reflect all the skills and knowledge required for some, especially entry level, engineering positions. Nevertheless, the information indicates that the graduating seniors believe their coursework has given them a strong background in the 11 educational outcomes required by ABET. 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 ABET objectives.

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Bibliography

1. “A vital first step.” (1996). *Engineering First,* Engineering Council, London, England.
2. “Compensation: no recoveries in sight.” (1994). *Engineers*, Engineering Workforce Commission of the American Association of Engineering Societies (AAES), 1(1), 1-6.
3. *Criteria for Accrediting Engineering Programs.* (2001). Engineering Accreditation Commission of the Accreditation Board for Engineering and Technol. (ABET), Baltimore, MD.
4. “Engineering could become just a technical degree.” (1995). *Civil Engineering*, ASCE, 65(8), 10-14.
5. *Engineering education for a changing world.* (1994). Am. Soc. For Engrg. Educ. (ASEE), Washington, D.C.
6. “Graduating Engineering Students.” (2002). *EBI Engineering Education e News*, (3), 2-3, www.webebl.com.

7. Koehn, E. (2001). "Assessment of Communications and Collaborative Learning in Civil Engineering Education." *J. Profl. Issues in Engrg. Educ. And Pract.*, ASCE, 127(4), 160-165.
8. Koehn, E. (2001). "ABET Program Criteria: Review and Assessment for a Civil Engineering Program." *Journal of Engineering Education*, ASEE, 90(3), 445-455.
9. Koehn, E. (1996). "Practitioner and student recommendations for an engineering curriculum." *J. Engrg. Educ.*, 84(3), 241-248.
10. Koehn, E. (1997). "Engineering Perceptions of ABET Accreditation Criteria", *J. Profl. Issues in Engrg. Educ. And Pract.,* ASCE, 123(2), 66-70.
11. *Manual of Evaluation Process: Engineering Criteria 2000.* (2002). Accreditation Board for Engineering and Technology (ABET), Baltimore, MD.
12. National Society of Professional Engineers (NSPE). (1992). "First professional degree survey report." *Publ. No. 059*, Alexandria, VA.
13. *News Release*. (2002). Accreditation Board of Engineering and Technology (ABET), Baltimore, MD.
14. "Profession at risk: why four years?" (1995). Background material for the ASCE 1995 Education Conference, ASCE, New York, N.Y.
15. "Re-engineering civil engineering education: goals for the 21st century." (1994). *Proc., Civ. Engrg. Workshop for the 1995 Civ. Engrg. Educ. Conf.,* ASCE, New York, N.Y., 11-12.

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