Assessment of ABET Program Criteria for Engineering Curricula

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Abstract

The Accreditation Board for Engineering and Technology (ABET) has adopted a revised set of criteria for accrediting engineering programs. Nevertheless, as in the past, civil (construction) engineering departments will be required to demonstrate proficiency in specific subject areas which are included in the ABET program criteria.

This paper investigates, according, in part, to construction related students, the level at which the subjects in the civil engineering program criteria have been considered in a specific curriculum. In particular, the findings suggest that both undergraduate and graduate students believe that 4 areas have been incorporated into the civil (construction) engineering program at a high level. These include: mathematics through calculus and differential equations, structural engineering, major design experience or course, and geotechnical engineering. In addition, 1 area, construction management, has been rated at a high level by graduate students.

I. Introduction

Over the years there have been recommendations from employers and various technical and professional organizations to revise the engineering curriculum to ensure that students are prepared for the professional practice of engineering.[5,12] Practicing engineers and educators have also indicated that they are not completely satisfied with the average engineering program.[9,10,11]

This paper reviews a number of recent recommendations involving engineering education and presents the result of an investigation of the perceptions of a group of undergraduate and graduate students. The data for the study was obtained from a survey instrument which was distributed to students enrolled, in part, in construction related courses taught in civil engineering degree programs. Respondents were requested to indicate whether, and at which level, various subject areas have been incorporated into the curriculum. The subjects chosen are those that have been included in the *Civil Engineering and Similarly named Program Criteria* that has been adopted by the Accreditation Board for engineering and Technology (ABET) and must be satisfied for a program to be accredited.[3] The findings of the investigation could be utilized, for comparative purposes, by other institutions and departments that may wish to study their curriculum.

II. Engineering Curriculum

Recently, engineering educators have indicated that, overall, effective teaching is rated as their highest priority.[1,2] Nevertheless, some authorities believe that a faculty member's role is not to teach but to help students learn.[6] In addition, it is believed that educators should assist students

to unlock their creative potential so that they may solve open ended interdisciplinary problems encompassing many subject areas.[7] An example would be to develop comprehensive skills to solve the nation's infrastructure problems. This concept, therefore, is especially applicable to the construction industry.

It has been suggested that successful engineering students should be involved with the following: schedule and time management, interaction with peers, interaction with the faculty, and involvement with student organizations.[13] Most of these items will also develop the concept of teamwork. Teamwork will be defined as the cooperative effort of individuals toward meeting a goal. Specifically, today, enthusiastic team leaders are needed by the construction industry to lead by example, articulation, inspiration, and most importantly by consent.[14]

To satisfy changing industrial needs and support, in part, the aforementioned concepts, ABET has adopted a revised set of criteria for accrediting engineering programs.[4] In particular, it is required that, in the future, engineering programs must demonstrate that their graduates have gained proficiency in or understanding of various items contained in the *Civil and Similarly named Engineering Programs Criteria.*[3] For informational purposes the particular subjects are listed in Table 1.

In addition to the above, all accredited programs must satisfy 11 educational attributes and ensure that realistic constrains are utilized in the design courses offered by the institution. A detailed study of these two aspects of the criteria was recently published.[8,9] In addition to the foregoing, each program must develop an assessment process and document the results. Specifically, the outcomes should be utilized to further develop and improve the engineering program(s) at the institution.

III. Undergraduate Perceptions of the Civil Engineering Program Criteria

As a segment of a continuing review of the curriculum, a survey instrument was distributed to students enrolled in required senior and typical construction related graduate courses offered by the Civil Engineering Department of Lamar University. The tabulated results of the study form the data base for the investigation. Specifically, the questionnaire listed various civil (construction) engineering program requirements and requested respondents to indicate at which level – high, average, low, or unsure/none – each presently is incorporated into the curriculum. The subject areas chosen are listed in a recently adopted set of criteria for accrediting engineering programs. They were included in the Civil Engineering Program Criteria section of the recent *Engineering Criteria 2000* report and are listed in Table 1.[4]

Specifically, the findings suggest that many of the subject areas have been incorporated into the curriculum at a reasonable level. For example, Table 1 illustrates that over 45% of the undergraduate students believe that 3 areas are being treated at a high category level. As shown, they include:

- Mathematics through calculus and differential equations
- Structural Engineering
- Major design experience or course

In addition, the following 2 subjects are perceived to be considered between 40-45% in the high level category:

- Geotechnical Engineering
- Hydraulics/Hydrology/Water Resources

The 5 areas listed above are perceived by undergraduate students to be covered at a relatively high level. They include many of the traditional technical aspects of engineering which may also be, in part, of prime interest to those in construction. Nevertheless, as shown in Table 1, 4 subjects are rated with a score below 15% in the high category. These include: probability and statistics, general chemistry, structural materials laboratory, and procurement of work. This indicates that additional attention and departmental/university resources may be necessary in these areas. However, approximately 40% of the undergraduates responding to the survey are required to enroll in at least one additional semester to complete their degree requirements. This includes taking construction management and senior systems design. It is not unreasonable, therefore, to assume that many undergraduate students have not been exposed to the concept of procurement of work at a high level of intensity. Therefore, the ratings most likely reflect the incomplete background of some respondent.

IV. Graduate Student Perceptions of the Civil Engineering Program Criteria

The perceptions of graduate students enrolled in construction related courses are shown in Table 2. Here, over 45% of the respondents indicate that 3 subject areas are covered at a high level. They include:

- Mathematics through calculus and differential equations
- Structural Engineering
- Construction Management/Surveying

In addition, the following 4 subjects are perceived to be between 40-45% in the high level category:

- Geotechnical Engineering
- Structural Materials Laboratory
- Hydraulics Laboratory
- Major design experience or course

Graduate students perceive that the aforementioned 7 areas are covered at a relatively high level. Four of these are also rated at a high level by undergraduates. They include: mathematics through calculus and differential equations, structural engineering, major design experience or course, and geotechnical engineering. The findings indicate that both graduate and undergraduate students appear to agree that certain subject areas should be considered at a high level in the civil (construction) engineering program. These courses also tend to include the traditional technical aspects of engineering.

Table 1. Undergraduate Students' Perceptions of ABET Civil Engineering Program Criteria

PROGRAM CRITERIA	Present Level of Program Criteria Subject Areas, As a Percentage of Respondents: High	Avg	Low	Unsure or None	*Composite Score
Proficiency in the following:					
Mathematics through calculus And differential equations	47.1	52.9	0.0	0.0	3.5
Probability and statistics	11.8	70.6	17.6	0.0	2.9
Calculus-based physics	29.4	64.7	5.9	0.0	3.2
General chemistry	11.0	70.6	17.6	0.0	2.9
Proficiency in at least four major civil engineering areas:					
Structural	58.8	35.3	5.9	0.0	3.5
Geotechnical	41.2	52.9	5.9	0.0	3.4
Environmental	29.4	41.2	29.4	0.0	3.0
Hydraulics/Hydrology/ Water Resources	41.2	52.9	5.9	0.0	3.4
Construction Management/ Surveying	23.5	58.8	17.6	0.0	3.1
Ability to conduct laboratory experiments and critically interpret data in more than one of the areas listed below:					
Structural	11.8	52.9	35.0	0.0	2.8
Geotechnical	17.6	64.7	17.6	0.0	3.0
Environmental	23.5	41.2	35.3	0.0	2.9
Hydraulics	35.3	52.9	11.8	0.0	3.2
Surveying	35.3	58.8	5.9	0.0	3.3
Ability to perform engineering design by the following:					
Design experiences integrated throughout the curriculum	35.3	64.7	0.0	0.0	3.4
Major design experience or course	47.1	41.2	11.8	0.0	3.4
Understanding of/or exposure to professional practice issues such as:					
Procurement of work	11.8	64.7	23.5	0.0	2.9
Bidding versus quality based selection	17.6	47.1	35.3	0.0	2.8
Interaction of design and construction professionals	23.5	47.1	29.4	0.0	2.9
Importance of professional licensure	35.3	47.2	23.5	0.0	3.1
Importance of continuing education	17.6	41.2	41.2	0.0	2.8

*Composite Score based upon 4.0 = High; 3.0 = Average; 2.0 = Low; 1.0 = Unsure/None

Table 2. Graduate Students' Perceptions of ABET Civil Engineering Program Criteria

PROGRAM CRITERIA	Present Level of Program Criteria Subject Areas, As a Percentage of Respondents: High	Avg	Low	Unsure or None	*Composite Score
Proficiency in the following:					
Mathematics through calculus and differential equations	50.0	50.0	0.0	0.0	3.5
Probability and statistics	40.0	40.0	20.0	0.0	3.2
Calculus-based physics	16.7	73.3	10.0	0.0	3.1
General chemistry	26.7	46.7	23.3	3.3	3.0
Proficiency in at least four major civil engineering areas:					
Structural	60.0	40.0	0.0	0.0	3.6
Geotechnical	43.3	46.7	10.0	0.0	3.3
Environmental	30.0	50.0	20.0	0.0	3.1
Hydraulics/Hydrology/ Water Resources	36.7	53.3	10.0	0.0	3.3
Construction Management/ Surveying	53.3	43.3	3.3	0.0	3.5
Ability to conduct laboratory experiments and critically Interpret data in more than one of the areas listed below:					
Structural/Materials	43.3	46.7	10.0	0.0	3.2
Geotechnical	23.3	56.7	20.0	0.0	3.0
Environmental	33.3	50.0	16.7	0.0	3.2
Hydraulics	43.3	36.7	20.0	0.0	3.2
Surveying	33.3	53.3	13.3	0.0	3.2
Ability to perform engineering design by the following:					
Design experiences integrated throughout the curriculum	40.0	53.3	6.7	0.0	3.3
Major design experience or course	43.3	43.3	10.0	3.3	3.3
Understanding of or exposure to professional practice issues such as:					
Procurement of work	36.7	50.0	13.3	0.0	3.2
Bidding versus quality based selection	40.0	36.7	23.3	0.0	3.2
Interaction of design and construction professionals	26.7	60.0	13.3	0.0	3.1
Importance of professional licensure	30.0	46.7	23.3	0.0	3.1
Importance of continuing education	26.7	50.0	20.0	3.3	3.0

*Composite Score based upon 4.0 = High; 3.0 = Average; 2.0 = Low; 1.0 = Unsure/None

V. Comparison of Civil Engineering Program Criteria

Tables 1-3 illustrate that the composite scores of undergraduate and graduate students tend to be similar for various subject areas. The composite score is based upon the following rating system: High = 4.0; Average = 3.0; Low = 2.0; and Unsure/None = 1.0. In particular, undergraduates rate the composite score of 11 subject areas slightly lower (between .1 - .4) than graduate students. In contrast, 6 subjects are rated slightly higher (between .1 - .3) by undergraduate students.

Table 3 shows that both undergraduate and graduate students rate 4 areas with identical composite scores. They include mathematics (3.5), geotechnical laboratory (3.0), hydraulics laboratory (3.2) and importance of professional licensure (3.1).

Tables 4 and 5 illustrate those areas that have a difference in composite score at either the .3 or .4 level. As shown, the values for undergraduate students are less than those of graduates. In the non-technical areas these include: construction management, bidding versus quality based selection, and procurement of work. However, as stated in a previous section, approximately 40% of the undergraduates responding to the survey are required to enroll in at least one additional semester to complete their degree requirement. Courses to be taken include construction management and senior systems design. It is not unreasonable, therefore, to assume that many undergraduate students responding to the survey have not been exposed to non-technical concepts at a high level of intensity. Therefore, the rating most likely reflect the incomplete background of some respondents.

VI. Summary and Conclusions

This paper reviews a number of recent recommendations involving engineering education. In addition, it presents the results of an investigation of the perceptions of a group of undergraduate and graduate engineering students, enrolled, in part, in construction related courses, concerning the level at which various civil engineering program requirements have been incorporated into the curriculum. Data for the study was obtained from a questionnaire which was completed by students enrolled in various civil (construction) engineering degree programs. The findings of the investigation could be utilized, for comparative purposes, by other institutions and departments that may wish to study their curriculum.

In particular, the results suggest that both undergraduate and graduate students believe that 4 subject areas have been incorporated into the program at a relatively high level. They include; mathematics through calculus and differential equations, structural engineering, major design experience or course, and geotechnical engineering. These include the traditional technical aspect of engineering education. It was found that graduate students, many of whom have considerable industrial and construction experience, tend to rate, overall, non-technical areas such as construction management, bidding versus quality based selection, and procurement of work at a higher composite score compared to undergraduates. This is not unexpected since 40% of the undergraduate respondents will be required to complete at least one additional semester to complete their course of study. This includes, for most students, the major design experience,

Table 3. Program Criteria with Identical Composite Scores

Subject Area	Level of Subject Area As a Composite Score* Undergraduate	Graduate
Mathematics through calculus and differential equations	3.5	3.5
Geotechnical laboratory	3.0	3.0
Hydraulics laboratory	3.2	3.2
Importance of professional licensure	3.1	3.1

*Composite Score based upon 4.0 = High; 3.0 = Average; 2.0 = Low; 1.0 = Unsure/None.

Table 4. Comparison of Subjects in Program Criteria with Differences in Composite Score = .3

Subject Area	Level of Subject Area As a Composite Score* Undergraduate	Graduate
Probability and statistics	2.9	3.2
Environmental laboratory	2.9	3.2
Procurement of work	2.9	3.2

*Composite Score based upon 4.0 = High; 3.0 = Average; 2.0 = Low; 1.0 = Unsure/None.

Table 5. Comparison of Subjects with Differences in Composite Score = .4

Subject Area	Level of Subject Area As a Composite Score* Undergraduate	Graduate
Construction management/ Surveying	3.1	3.5
Structural/materials laboratory	2.8	3.2
Bidding versus quality based selection	2.8	3.2

*Composite Score based upon 4.0 = High; 3.0 = Average; 2.0 = Low; 1.0 = Unsure/None.

project management, and construction electives. The ratings, therefore, most likely reflect the incomplete academic background of some undergraduates.

Generally, the findings suggest that students appear to perceive that the civil (construction) engineering program criteria have been incorporated into the curriculum at a reasonable level. These subject areas will be required by ABET as criteria that must be satisfied for a program to be accredited. Specifically, the *Civil and Similarly named Engineering Programs Criteria* is included as a section of the *Engineering Criteria 2000* report which was adopted by ABET. It is hoped that consideration of the foregoing concepts by educators will provide engineering students with the skills required for a successful career involving the design and management of engineering and construction projects.

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Biography

Enno "Ed" Koehn is Professor and Chair of the Department of Civil Engineering at Lamar University, Beaumont, TX. Professor Koehn has served as the principal investigator for several research and development projects dealing with various aspects of construction and has experience in the design, scheduling, and estimating of facilities. In addition, he has authored/co-authored over 100 papers in engineering education and the general areas of civil and

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