Assessment of Student Ability to Identify Engineering Problems

M. Armstrong, G. Bull, and A. Biaglow
Department of Chemistry and Life Science
Chemical Engineering Program
United States Military Academy
West Point, NY 10996

Abstract

The ability to identify an engineering problem is an important skill that has been identified by ABET as part of its accreditation criteria. Specifically, student outcome (e) in Criterion 3 requires the ability to identify, formulate, and solve engineering problems. A great deal has been written about how engineers formulate and solve problems, but very little information is available on how engineers identify problems, even less on how this skill is assessed. For the most part, engineering programs focus on assessing formulation and solution, and assume that identification is a natural part of that process. In this paper, we discuss a test that we have developed to directly assess our student's ability to identify engineering problems. The results show that our students possess the ability to a degree, and that this ability develops with the amount of student experience. Furthermore, by comparing the test results from those of the students to those obtained form more experienced engineers, we are able to directly assess the degree to which our students have developed the ability.

Keywords

Assessment, ABET, criterion, recognize, engineering.

Introduction

Engineers graduating from ABET-accredited programs are expected to be able to identify engineering problems. The skill is identified in Criterion 3 of the *Criteria for Programs*, which lists the required student outcomes.[1] According to student outcome (e), at the time of graduation, students will have "an ability to identify, formulate, and solve engineering problems." A considerable amount of information is available on theory and practice relating to this outcome.[2-5] However, while most assessment protocols do a good job on formulation and solving, it is difficult to find information on the direct assessment of students' ability to *identify* engineering problems. Identification is almost never directly assessed.

An interesting example from a student's perspective is provided by the portfolio of David Knight, a recent graduate of Texas A&M. In his portfolio, David comments specifically about ABET outcome e.[6] He explains that one of his skills is that he can identify, formulate, and solve engineering problems. He goes on to say that he learned how to recognize the nomenclature of Chemical Engineering, how to use a systematic approach to solve Chemical Engineering problems, and how to use an accounting framework to solve material and energy balance problems. David is simply reciting the course objectives from his Elementary Chemical Engineering course. The emphasis in this course was clearly on nomenclature and solving. The connection to identification is indirect at best. Presumably, understanding chemical engineering nomenclature can help identify a problem. However, problems that a chemical engineer might solve could also be posed without chemical engineering nomenclature. Nowhere in the portfolio does David explain how he might characterize a problem as chemical engineering, chemistry or mathematics, or as being within his area of expertise. David might actually end up with a job where he has to transform an ill-defined problems in terms of chemical engineering.

Another interesting example from the institutional perspective is provided by Dartmouth University.[7] The citation provides an excellent review of the problem solving cycle, which includes stating the problem, defining the problem, identifying constraints and setting general specifications, identifying alternate solutions, selecting the most viable alternative, redefining the problem, refining and adding specifications, brainstorming alternatives, iterating solutions, and selecting the most viable solution. While comprehensive and clear, the approach assumes that the problem can or should be solved by engineers. It also appears that the method is designed to help students after the problem is already presented to them. The Dartmouth method does not mention a step where the student is asked what type of problem they are looking at, who is best qualified to address the problem or what type of interdisciplinary team should be assembled to solve it.

In our internal assessment process, we decided to address this issue directly. That is, we provided our students with a series of questions and asked them to determine whether the questions relate primarily to engineering, basic science, mathematics, or some other discipline. The hypothesis is that the assessment of ET content in a problem will depend on the background of the person making the assessment. The following survey described in the report is an attempt to test that hypothesis.

Methods

The survey consists of three parts. The first part of the survey requires the survey respondent to provide data about their own personal background and experience, particularly in engineering, mathematics, or science. The second part of the survey is a list of problems. The survey participants are asked to read each question and complete a short multiple choice question that asks them to rank the amount of engineering, math or basic science content in the problem. A third section of the survey, not discussed here, asks the respondents to assess the quality of the survey itself. Tables 1 and 2 show examples of the survey questions and the instructions that were provided to the survey takers.

The survey is intended for different groups of respondents, including junior and senior students in our program, engineering faculty, science faculty, and the chemical engineering advisory board. Some of the engineering faculty are trained as ABET program evaluators and we grouped their results separately. Using these different study groups allowed us to compare similar groups at various levels of experience to build our confidence in the results.

Table 1. Background questions for faculty, advisory board members, and PEVs.

In this part of the survey we would like you to tell us a little about yourself. The purpose is to learn a little bit about your perspective in order to analyze the data from Part 2 of the survey. For each question or statement below, darken the box next to the answer that correctly completes the statement. Provide only one answer per question.

1. My bachelor's degree is in
   ☐ engineering ☐ science ☐ mathematics ☐ other

2. My master's degree is in
   ☐ engineering ☐ science ☐ mathematics ☐ other ☐ N/A

3. My doctorate degree is in
   ☐ engineering ☐ science ☐ mathematics ☐ other ☐ N/A

4. Over the last 3 years, my primary job function has been as
   ☐ an engineer ☐ a scientist ☐ a mathematician ☐ other

5. In general, I consider myself to be
   ☐ an engineer ☐ a scientist ☐ a mathematician ☐ other.

6. Over the last 3 years, the number of engineering projects I have been involved is
   ☐ none ☐ 1-3 ☐ 4-6 ☐ > 6

7. Over the last 3 years, the number of fundamental or basic science research projects I have been involved is
   ☐ none ☐ 1-3 ☐ 4-6 ☐ >6

8. Beyond graduate school, how many years of professional experience in mathematics, science, or engineering do you have?
   ☐ less than 3 ☐ 3-6 ☐ 7-10 ☐ 11-20 ☐ >20

9. Beyond graduate school, my total number of years of professional experience, in any capacity, is
   ☐ less than 3 ☐ 3-6 ☐ 7-10 ☐ 11-20 ☐ >20

10. The courses that I teach are primarily
    ☐ engineering ☐ science ☐ mathematics ☐ other ☐ Don't teach

11. The students, interns, or other professionals that I interact with are primarily
    ☐ engineers ☐ scientists ☐ mathematicians ☐ other ☐ N/A

Table 2. Background questions for junior and senior students.

In this part of the survey we would like you to tell us a little about yourself. The purpose is to learn a little bit about your perspective in order to analyze the data from Part 2 of the survey. For each question or statement below, darken the box next to the answer that correctly completes the statement. Provide only one answer per question.				
1. My undergraduate degree will be in				
☐ other	☐ science	☐ mathematics	☐ chemical engineering	
2. In general, I see myself as more of				
☐ an engineer	☐ a cadet	☐ both	☐ other	
6. Over the last 3 years, the number of engineering courses I have taken is				
☐ none	☐ 1-3	☐ 4-6	☐ > 6	
7. Over the last 3 years, the number of fundamental or basic science courses I have taken is				
☐ none	☐ 1-3	☐ 4-6	☐ >6	
11. The cadets and faculty that I interact with are primarily				
☐ engineers	☐ scientists	☐ mathematicians	☐ other	☐ N/A

Table 3. Rubric used to assess engineering content in the survey questions. Samples of the survey questions are shown in Table 4.

	Great extent		Moderate		Not at all
To what extent is this a mathematics problem?	☐	☐	☐	☐	☐
To what extent is this a basic science problem?	☐	☐	☐	☐	☐
To what extent is an engineering problem?	☐	☐	☐	☐	☐
To what extent is this some other type of problems?	☐	☐	☐	☐	☐

Table 4. Sample questions used in the survey. Respondents are asked to identify the problem as mathematics, basic science, engineering or other according to the rubric in Table 2.

1. An insulated cable placed in the Atlantic Ocean connecting the United States to the United Kingdom is used for telecommunications. Symptoms develop in the operation of the cable indicating the possibility that a hole may haves formed in the insulation. Discuss possible methods for finding (i) whether or not a hole has in fact formed, and (ii) the location of the hole, if it exists.

2. The *Blavier method* has been used with great success in troubleshooting undersea cables, and was developed by the French engineer Eduard Blavier (1826-1887). The method can be used to identify and find the location of ground faults in very long cables. The two equations shown below follow from the method. If a, b, and c are positive real constants, solve for x and y. Do any combinations of a, b, and c lead to negative or imaginary solutions?

$$b = x + y, \text{ and } c = x + \frac{y \cdot (a - x)}{y + a - x}$$

In these equations, x is the resistance of the cable up to the fault, and y is the resistance from the fault through the sea water to earth ground. The constants b and c are the measured resistances in the cable with one end of the cable open and closed, respectively. The constant a is the total resistance of the cable. If you know the resistance per length for the cable, you can use the value of x to find the location of the fault.

5. You wish to design a coating (paint) for walls and other vertical surfaces. After some research, you decide that the coating is to be applied “wet” after which it will dry to a smooth finished surface within a few hours. However, the coating must remain on the surface during the drying phase. That is, it cannot run, and the thickness of the coating must remain more or less uniform in the vertical direction. Identify the properties of the coating and the surface that are relevant to this problem. Use this information to develop a mathematical model to predict the thickness of the coating as a function of time.

8. A Fischer-Tropsch chemical reactor uses a catalyst to convert carbon monoxide and hydrogen into methane and higher molecular weight hydrocarbons. This is sometimes referred to as Gas-to-Liquids, or simply GTL technology. A newly developed catalyst is being studied for possible use in a GTL plant. The catalyst contains cobalt impregnated into a solid porous alumina support. The impregnation process involves wetting the support with cobalt nitrate solution, then drying in a furnace under a nitrogen atmosphere at 800 °C for 8 to 10 hours. The result of this treatment is believed to be the formation of small (~80-90 Å) particles of metallic cobalt separated by regions of catalyst where there is no metal. The CO and H_2 molecules can then interact with the metal surface, which is catalytic. The manner in which the molecules interact with the catalyst is not well-understood. Research and describe at least two measurement techniques that can be used to probe the interactions between the molecules and the metal surface, and explain what specific information the methods will provide.

Table 5. Attributes of chemical engineering faculty and advisory board (FAB, n=13), program evaluators (PEV, n=8), and science faculty (SCI, n=7). Data are formatted so that the number of responses is displayed as FAB / PEV / SCI.

#		Engineering	Science	Math	Other	N/A
1	B.S. degrees	9 / 6 / 0	3 / 1 / 7	0 / 0 / 0	1 / 1 / 0	
2	M.S. degrees	9 / 6 / 0	0 / 1 / 6	0 / 0 / 0	2 / 1 / 0	2 / 0 / 1
3	Ph.D.'s	6 / 6 / 0	0 / 1 / 5	0 / 0 / 0	0 / 1 / 0	7 / 0 / 2
4	Primary job function	8 / 5 / 0	1 / 1 / 6	0 / 0 / 0	4 / 2 / 1	
5	I consider myself to be	12 / 6 / 0	0 / 1 / 6	0 / 0 / 0	1 / 1 / 1	
10	Courses that I teach	5 / 6 / 0	1 / 1 / 7	0 / 1 / 0	1 / 0 / 0	5 / 0 / 0
11	People I interact with	8 / 7 / 0	1 / 0 / 6	0 / 1 / 0	2 / 0 / 1	1 / 0 / 0
		None	1-3	4-6	>6	
6	Number engineering projects	3 / 0 / 5	5 / 3 / 2	0 / 0 / 0	5 / 5 / 0	
7	Number basic science projects	6 / 5 / 0	6 / 2 / 3	0 / 0 / 3	1 / 1 / 1	
		<3	3-6	7-10	11-20	>20
8	Years of experience in MSE	2 / 0 / 2	1 / 1 / 2	2 / 1 / 0	3 / 3 / 1	5 / 3 / 2
9	Years of total experience	0 / 0 / 2	1 / 1 / 2	2 / 1 / 0	4 / 3 / 1	6 / 3 / 2

Table 6. Attributes of the junior (n=12) and senior (n=16) chemical engineering cadets in the survey. Data are formatted so that the number of responses is displayed as juniors / seniors.

#		Engineering	Science	Math	Other	N/A
1	My undergrad degree will be in	12 / 16	0 / 0	0 / 0	0 / 0	---
11	Cadets & faculty I interact with	8 / 15	2 / 0	0 / 0	2 / 1	---
		Engineering	Cadet	Both	Other	
2	Generally I see myself as	2 / 5	2 / 3	7 / 8	1 / 0	
		None	1-3	4-6	>6	
6	Number engineering courses taken	0 / 0	5 / 0	7 / 1	0 / 15	
7	Number science courses taken	0 / 0	6 / 1	4 / 6	2 / 9	

Results

Table 5 shows the relevant attributes of the faculty and advisory board members. The main feature of this data are that the survey takers have a strong sense of identity, whether as engineers or as scientists. That is, the engineers in the survey see themselves as engineers, have university degrees in engineering, teach engineering courses, interact primarily with other engineers, and have worked on what they believe to be engineering projects. The science faculty in the survey have similar views about themselves.

Table 6 shows the attributes of the students. The sense of identity is not as strong here as it is with the faculty and advisory board members, which is completely understandable for undergraduate students. For the most part, they recognize that their degree will be in engineering and that they interact with other engineering students and faculty. They also indicate, for the most part, that they see themselves as engineers. We note that the seniors display these attributes more so than the juniors. This is perhaps not surprising since they are significantly further along in the curriculum.

An example of the survey results is shown in Figure 1. The figure shows the responses of the ABET PEV study group to the Table 3 questions pertaining to the first question in Table 4. The horizontal axis indicates the content areas from Table 3. The vertical axis shows the response, where the extent of content in Table 3 was converted to a 1-5 numerical rating scale for analysis. A response of 5 indicates that the respondent saw a strong amount of content, and a 1 indicates no content. The instructor's rating, which is the expected or desired outcome, is shown as the left-most bar in each group.

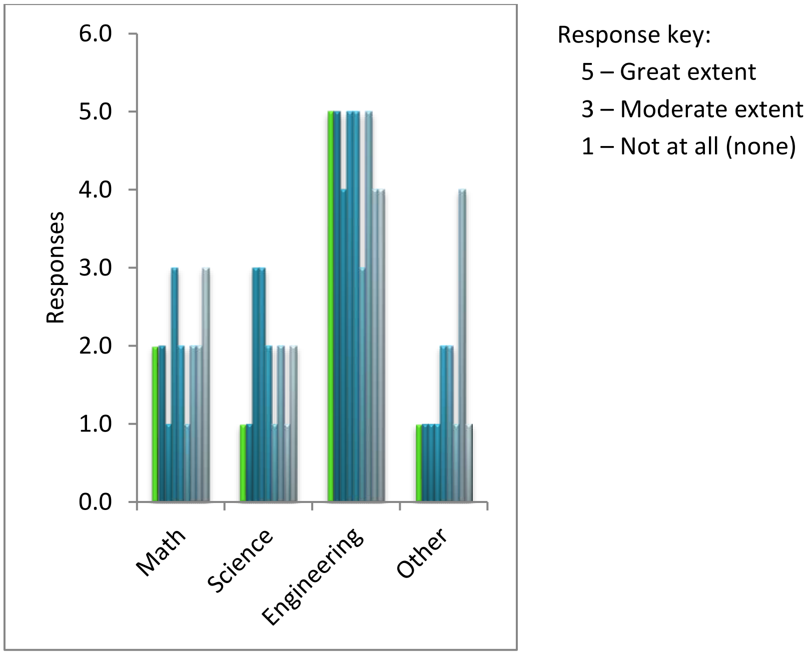

Figure 1. Responses of the PEVs to Problem 1 in Table 4. The instructor's rating is shown for comparison as the left-most (green) bar in each group.

Figure 2 shows a summary of the results for question 1 in Table 4 for each of the five study groups. Starting with data like that shown in Figure 1, we took the mean, min, and max scores and plotted them in Figure 2, and Figures 2(a) through (e) show the results for each of the different groups. This presentation allows us to visually compare the instructor's (problem author's) rating to those of each the different groups. The figure shows that we have very good agreement between the various groups that this is indeed an engineering problem.

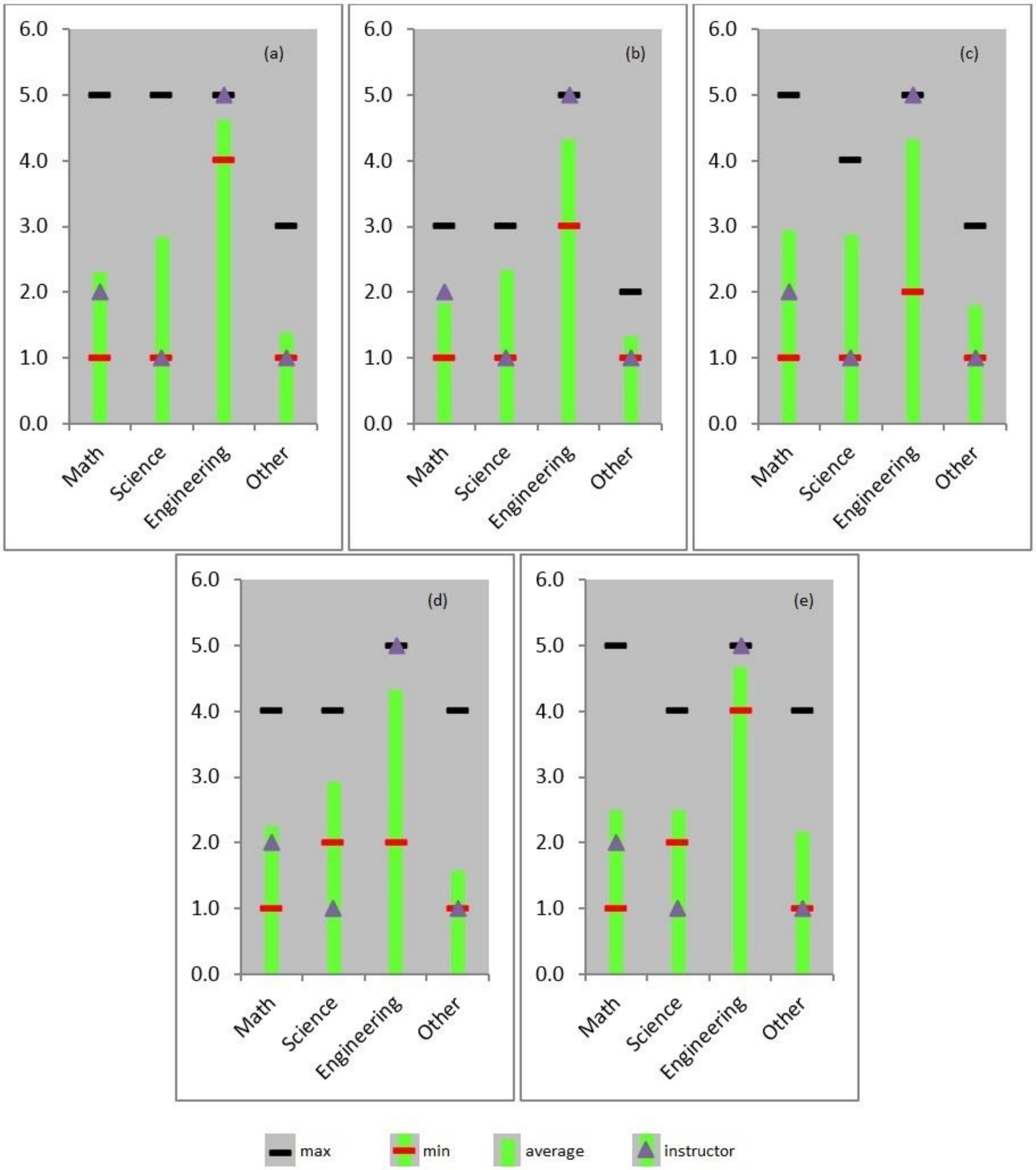

Figure 2. Survey results for Table 4 Problem 1 for (a) engineering faculty and advisory board, (b) ABET PEVs, (c) science faculty, (d) senior chemical engineering students, and (e) junior chemical engineering students. A similar set of plots was obtained for all 14 questions.

The results for the five different study groups for all 14 problems are summarized in Table 7. These results came from direct visual comparison of the data. That is, the green bars were compared to the instructor's assessment (triangles). Agreement is indicated in the table with a check mark (✓) if the highest average response matched the instructor's intent. The cross marks (✗) indicate disagreement in the maxima. For example, in Figure 2a, the highest survey average (engineering) is close to the instructor triangle, resulting in a check mark in Table 7 for Question 1 for the advisory board and faculty. Overall, the data show that the chemical engineering faculty and advisory board members agree with the instructor on 13 out of 14 of the question. Also, by this analysis, the faculty and advisory board essentially agrees 100% with the ABET program evaluators. This is a key result, since it provides a measure of consistency in the survey between two very different and independent groups.

Table 7. Agreement between study groups in the engineering content survey.

Question	ChE Faculty and Advisory Board	USMA PEVs	USMA ChE Seniors	USMA ChE Juniors	USMA Science Faculty
1	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓
3	✓	✓	✓	✗	✗
4	✓	✓	✓	✓	✓
5	✓	✓	✓	✓	✓
6	✓	✓	✓	✓	✓
7	✓	✓	✓	✓	✓
8	✓	✓	✗	✗	✓
9	✓	✓	✓	✓	✗
10	✓	✓	✓	✓	✓
11	✓	✓	✓	✗	✗
12	✓	✓	✓	✓	✓
13	✗	✗	✓	✓	✗
14	✓	✓	✓	✓	✓
Average	78.0±6.5 (N=13)	79.0±7.2 (N=8)	72.2±8.1 (N=16)	74.1±7.6 (N=12)	74.9±6.7 (N=7)

The bottom row of Table 7 shows an average score ± standard deviation. The scores for each study group are a percentage of the instructor's score, from the following equation:

$$\text{Respondent's Score} = 100\,\frac{\overbrace{\sum_{j=1}^{14}\sum_{i=1}^{4}\left(\left|y_{ij}-3\right|+2\right)}^{A}-\overbrace{\sum_{j=1}^{14}\sum_{i=1}^{4}\left|x_{ij}-y_{ij}\right|}^{B}}{\underbrace{\sum_{j=1}^{14}\sum_{i=1}^{4}\left(\left|y_{ij}-3\right|+2\right)}_{A}} = 100\,\frac{A-B}{A}.$$

The term labeled “A” in the denominator is the maximum total deviation from the instructor’s responses, and “B” is the deviation of the respondent’s scores from the instructors’. The y-values are the instructor’s (problem author’s) ratings, and the x-values are the respondent’s ratings.

The determination of a score can be illustrated with an example. Consider the responses in Figure 2a. The instructor’s scores are 2, 1, 5, and 1 for this question. Since the maximum score for each category is a 5 and the minimum is a 1, the respondents’ scores can differ from the instructor’s by no more than 3,4,4, and 4. The inner summation (i=1 to 4) in the A-term sums the deviations (3+4+4+4=15), resulting in a total possible deviation of 15 for Problem 1 (j=1). The outer summation then adds the deviations from the 13 remaining questions (j=2,3,…14) to this. The A-term thus computes the total possible deviation from the instructor’s scores over all 14 problems (j=1,2,…14). The B-term computes the deviation of the respondent’s scores from the instructor’s. The calculation places the scores on a scale that can vary from 0 to 100%, with 100% being a perfect match between the respondent and the instructor. For example, if the respondent had given the exact same responses as the instructor, the deviations (B) would be zero and they would receive a score of 100. The respondent would receive a score of 0 if they responded in such a way as to maximize the deviations. The scores determined in this manner for each respondent are shown plotted in Figure 3 with overall averages in Table 7.

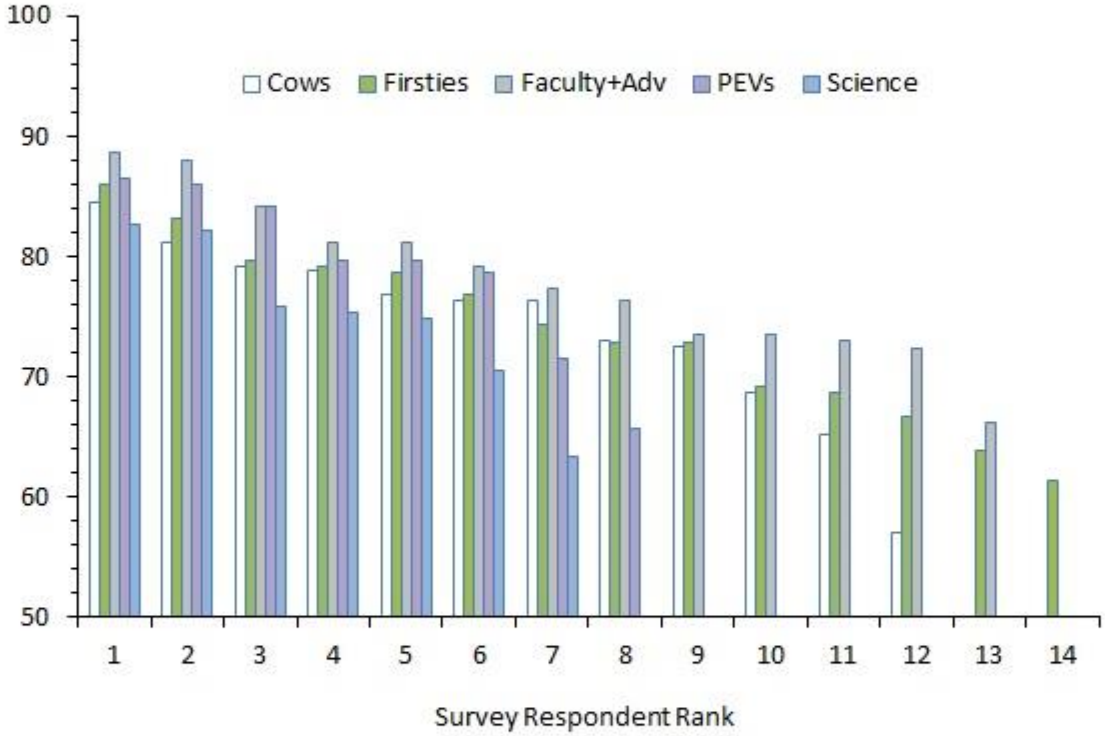

Figure 3. Ranked scores of individual respondents in the five study groups.

The averages in Table 7 lend themselves to further statistical analysis. We can use Student’s t-test to determine whether or not the differences in the mean scores are significant. For example, the confidence interval can be calculated for the difference between any two study groups. For example, the confidence interval can be calculated for the difference between the faculty and advisory board and the students. We have done this analysis, and in this case, we see a significant difference in means at the 80% confidence level.

Another useful feature of the averages is that a quantitative scale can be developed to designate level of agreement at the individual problem level in order to automatically assign the checks and crosses in Table 7. Doing this for our data, instead of visual inspection, requires a "passing score" of 68% to filter the data and generate the results shown in Table 7.

Discussion

The main purpose of this survey was to determine the ability of students to reliably identify engineering content. This skill and its assessment appears to be missing from the published literature, although our literature review is ongoing. The references cited earlier do not contain any mention of this other than a rather ambiguous lumping of the skill along with "formulate" and "solve." Felder and Brent[5] come very close and discuss the importance of identification of course content in planning a curriculum. We are still seeking examples of how programs assess identification.

While this paper has focused primarily on ABET Criterion 3e, the importance of properly identifying course content cannot be understated. The amount of engineering content in a curriculum is very important for ABET criterion 5, which calls for a specific amount of engineering topics (ET). ET includes engineering science and engineering design, which are defined by ABET as follows:

> "The engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other. Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs."

Since ET is differentiated from mathematics and basic science in this definition, it is also useful to consider ABET's definition of these topics:

> "Basic sciences are defined as biological, chemical, and physical sciences."

Interestingly, mathematics is not specifically defined in the ABET criteria, even though mathematics can range from pure to applied. Applied mathematics can be very difficult to differentiate from basic science or engineering, especially when the mathematical models are developed and applied to physical systems or devices. Often, mathematics courses are differentiated by the title and focus of the course, the background of the person teaching the course, the nature of the textbook, and the placement of the courses in the curriculum. For example, courses such as Calculus I and II occur early in the curriculum, tend to be taught by mathematicians, and focus on mathematical techniques, solving equations, and proofs. The issue becomes hazy in courses such as engineering mathematics, in which motivational descriptions of engineering systems often lay the groundwork for solutions of purely mathematical problems. Also, Engineering Mathematics is sometimes taught by engineering faculty, giving the course a very different perspective than would be given by a mathematician.

It is our opinion that the definitions are intentionally open-ended to allow programs flexibility in the design of their curricula. However, because of this, the definitions are also open to some amount of interpretation, and there is a considerable gray area separating engineering from mathematics and basic science, especially in an academic setting. Nevertheless, using these definitions, programs are expected to quantify the total amount of time spent by students in the program. According to ABET, this can be done either in terms of total time or credit hours. However, programs almost never use total time because of overlap in the curriculum with non-engineering requirements of the school. So as a result, Criterion 5 requires a breakdown of the courses in the curriculum by credit hour type in the self-study questionnaire.

Criterion 5 requires programs to have a minimum of 48.0 credit hours, or approximately a year and a half of ET in their curricula. While many programs are significantly beyond, some programs are near the minimum. These programs tend to be in schools where student time is constrained by other activities. For example, a school might have a requirement for a significant humanities or general education requirement that students must satisfy in addition to their engineering courses. These programs sometimes use courses in which engineering is not typically taught to boost the total number of engineering credit hours in the program. Programs claiming this credit have an obligation to ensure that the content is actually present. In programs that are well above the minimum, which is usually the case, credit hour justification is normally not an issue. The uncertainty in the credit hour content would be small enough with respect to the total that even if one or two courses get eliminated from the credit hour count, the program is still above the minimum. However, the issue becomes serious for programs that are at or near the minimum, where the courses are subdivided, especially when the courses are taught in mathematics or basic science departments.

For the ABET PEVs, the issue is determining what exactly comprises engineering content, and the ABET definitions are vague. Differentiation of content often boils down to a simple judgement call. PEVs are very diverse, but for the most part consist of people with a significant engineering background. Because of the importance of Criterion 5, the survey shown here, or a similar survey designed by a program to suit its own needs, would give great insight into how an ABET PEV might view the course. This information would allow a program to carefully assess credit hours in the program in preparation for the site visit.

A survey similar to the one described in this paper could be implemented at the course and program level. Table 8 provides hypothetical results for such an exercise. This hypothetical exercise includes more granularity in the levels of engineering content that might assist a curriculum planner. The table shows a list of homework problems assigned in a hypothetical Engineering Mathematics course. After review, the problems are binned by the reviewer into categories. A *basic* problem (B) is one that asks the student to perform a straight-forward task or to demonstrate understanding of fundamental concepts. A *contextual* problem (C) is one that asks for straight-forward statistical calculation but does so in the context of an engineering setting. An *applied* problem (A) is one that asks the student to perform some form of analysis of engineering-related data and then interpret the results or draw some engineering conclusion. A *design* problem (D) is basically a more involved and open-ended applied problem. It usually requires the student to develop a problem solving strategy, apply several statistical concepts, interpret the results, decide upon some action, and act on the decision. These (or similar) definitions should be provided to the reviewers along with the ABET definitions.

Table 8. Hypothetical survey results from a review of a program course in engineering mathematics.

Basic (B)	Contextual (C)	Applied (A)	Design (D)
3.11	2.1	2.38	4.36
3.157	2.5	3.1	6.23
3.158	2.24	3.25	7.10
3.18	2.3	3.26	7.11
3.71	2.4	2.21	6.28
3.81	4.11	3.35	7.13
3.91	4.12	3.36	7.14
3.104	4.13	3.4	4.40
3.94	2.23	3.7	7.17
3.105	2.159	4.28	7.26
	4.38	6.4	7.30
	3.129	3.43	7.31
	4.35	6.6	7.21
	6.10	7.1	7.34
	6.14	7.7	7.35
	6.32	3.6	8.1
	6.33	7.16	8.3
	3.75	7.2	8.13
	3.89	7.23	8.22
	4.49	7.24	8.23
	4.50	4.48	8.27
	4.97	4.29	8.29
	2.17	7.37	
	3.28	7.38	
Subtotals (number of problems in each category)			
10	24	24	22
Total number of problems: 80			
Fraction of engineering problems (A+D)/80: 0.58			

Assuming that this is a 3-credit course, the review in Table 8 would result in 1.7 credit hours of engineering topics (0.58×3.0) that could be applied toward satisfying ABET Criterion 5.

Conclusions

The ability to distinguish engineering problems from other types of problems is an important skill that is required by accreditation criteria. Based on the results shown in this paper, the ability to make this determination depends on the level of experience of the person making the assessment. We really do not have a concise definition of engineering from ABET, but it is fair to say that while we cannot really define engineering content, we know what it is when we see it.

The ability to make this determination is a judgement call that depends on experience and background. Specifically, to summarize the results shown here:

- Student's ability depends on level of exposure to other similar types of problems.
- Science and engineering faculty differ widely in their ability to assessment engineering content.
- Chemical engineering faculty and advisory board perspectives are similar and consistent with ABET PEVs, despite significant differences in level of practical experience.
- ABET program evaluators for the most part get it right and appear to provide a reliable assessment of engineering content.
- This is not a skill that is taught but rather an attribute that develops with experience.

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Matthew Armstrong

LTC Matthew Armstrong, Ph.D. is a Nuclear and Counterproliferation Officer with 20 years serving on active duty in the U.S. Army. Currently he is serving as an Assistant Professor at the United States Military Academy with 4 years of teaching experience. He has taught several courses in chemistry and chemical engineering. He is a member of the ASEE, AIChE and SOR.

Geoffrey Bull

Lieutenant Colonel Bull is a Nuclear and Counterproliferation Officer in the United States Army, currently an Assistant Professor at the United States Military Academy. Five of his 20 years of military experience have been spent teaching. He has taught general chemistry and physics courses, as well as both nuclear and chemical engineering electives. He is a member of ASEE and ANS.

Andrew Biaglow

Dr. Biaglow is a professor of chemical engineering at the United States Military Academy and has 23 years of teaching experience. He has developed and taught numerous courses in chemistry and chemical engineering. He is a member of the ASEE and the AIChE, and has been an ABET program evaluator since 2008.