A Plan to Assess All the New ABET Outcomes Using Only Three Courses

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Abstract

With ABET's Engineering Area Delegation voting in October 2017 to approve new versions of student outcomes to replace the ubiquitous a-k with which universities have struggled for years, many are concerned about what changes would mean and how the new versions could be assessed. As the new criteria are now official, programs have already begun to wrestle with dilemmas such as "what does 'communicate effectively with a range of audiences' mean?" and "how do we measure 'engineering judgement'?" This paper discusses the new outcomes and other changes to the EAC criteria, and describes the assessments, some planned and some on-going, which are being used to assess all outcomes in a program at the University of Tennessee at Chattanooga. This paper can serve as a reference for those wishing to address the new criteria, and can be used to start discussions on the critical topic of ABET assessment.

Keywords

ABET assessment, outcomes

Introduction

In October 2017, ABET's Engineering Area Delegation voted to approve new versions of student outcomes to replace the a-k outcomes which have been in place, essentially unchanged, since the late 1990s. The planned effective date of the changes is fall 2019.[1] Unlike the previous major change to EC2000, which included a transition period in which programs coming up for accreditation could choose whether to be accredited under the old or the new criteria, what is projected for the current changes is a "hard roll-out" that would require that all programs being visited in fall 2019 to qualify under the newly revised criteria.

Programs cognizant of the changes have begun to question whether the new version of the outcomes will require a complete retooling of existing assessment practices and methods, or whether it is a more incremental change that will work with many of the same assessment processes already being performed. Based on the author's extensive experience as an ABET program evaluator and as a commissioner on the EAC, the new Computer Engineering program at the University of Tennessee at Chattanooga has considered the assessing of the newly proposed criteria while also dealing with the difficulty of acquiring appropriate artifacts for assessment from other programs and departments. As a solution, the program assessment committee has developed a plan to assess all of the seven new outcomes in a set of only three courses: a computer ethics course required of all majors, and the two semesters of the Computer Engineering capstone design course. While page limitations prevent the entire assessment plan being detailed here, the main points are discussed, with illustrations of competencies leading to the achievement of the outcomes. Other changes to the criteria and addition of definitions of terms as used by ABET are also discussed.

Addition of Definitions

The newly approved version of the criteria includes detailed definitions of several terms which have been open to interpretation previously. This will provide a more uniform application of ABET criteria by program evaluators, and will lead to a more consistent experience for programs regardless of the evaluation team composition. Some of the terms now defined include Basic Science, College-Level Mathematics, Engineering Science, and Team.[1] However, the two which may be most helpful, especially to programs new to the EAC evaluation process, are those for Complex Engineering Problems and Engineering Design. The definition of Complex Engineering Problems states:

> Complex Engineering Problems - Complex engineering problems include one or more of the following characteristics: involving wide-ranging or conflicting technical issues, having no obvious solution, addressing problems not encompassed by current standards and codes, involving diverse groups of stakeholders, including many component parts or sub-problems, involving multiple disciplines, or having significant consequences in a range of contexts.[1]

Since the new version of Criterion 3 requires that all students "identify, formulate, and solve complex engineering problems,"[1] it is appropriate that ABET define what is meant by "complex engineering problems." Some programs have, in the past, defined "engineering problems" (as required in the current version of the criteria)[2] in terms of mathematical problems or simple design problems, such as designing a sequence detector in a digital logic class. These will plainly not meet the new ABET definition. In order to include the complexity required in the new standard, many programs may find the capstone design to be the most intuitive place in the curriculum to address this requirement. This leads to the new definition of Engineering Design:

> Engineering Design – Engineering design is a process of devising a system, component, or process to meet desired needs and specifications within constraints. It is an iterative, creative, decision-making process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources into solutions. Engineering design involves identifying opportunities, developing requirements, performing analysis and synthesis, generating multiple solutions, evaluating solutions against requirements, considering risks, and making tradeoffs, for the purpose of obtaining a high-quality solution under the given circumstances.[1]

The current version of the criteria do contain a definition of Engineering Design in Criterion 5: "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. "[2] The new definition makes it much clearer that design is expected to be both creative and iterative, and more clearly elaborates some of the aspects of the design process to be included. This will ensure that program graduates will not only have participated in a project which produces a product of some sort, but will also have a more extensive understanding of an overall engineering design process than was previously required.

Changes to Criterion 5

While most of the discussion regarding the changes to the EAC criteria have centered around the changes to the outcomes in Criterion 3, there is some significant change in Criterion 5. In addition to the move of the definition of engineering design to the Definitions portion of the Criteria, and a change in arrangement of the criterion to more clearly indicate that a major design experience is a requirement with equal importance to required number of hours in major curricular elements, there is a significant change to the number of hours required in the categories of mathematics and basic sciences, and engineering topics. The current version of the Criterion requires “one year” of math and basic sciences, and “one and one-half-years” of engineering topics[2] where a “year” is defined as “the lesser of 32 semester hours...or one-fourth of the total credits required for gradation.” The new version gives absolute minimums of 30 semester hours, or the equivalent, for mathematics and basic sciences and 45 for engineering topics.[1] This resolves a conundrum with the current criteria: if, for example, a program with a total of 120 semester hours included 45 hours of engineering topics, it would be deemed to have met the criterion, where a 128-hour program with 46 or 47 hours could be considered deficient. Also potentially significant is the explicit inclusion for the first time of computer science in the category of “engineering topics appropriate to the program.” Whether or not computer science courses met the definition has been the subject of frequent debate on EAC evaluation teams, but the EAC has now made clear its intention that they be included.

The New Outcomes in Criterion 3

The eleven EAC outcomes, a-k, under the newly approved Criterion 3, are reduced to seven:

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
(3) an ability to communicate effectively with a range of audiences
(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
(5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.[1]

Some of these appear quite familiar: for example, outcome 1 is clearly a simple combination of outcome a) "an ability to apply knowledge of mathematics, science, and engineering" and e) "an ability to apply knowledge of mathematics, science, and engineering" from the previous set,[2] with the addition of the work "complex" to "engineering problems." Others are now more explicit. For example, the previous outcome d) requires students "to function on multidisciplinary teams."[2] The new outcome 5 removes the word "multidisciplinary," but adds multiple specific items, such as "provide leadership," "establish goals," and "meet objectives,"[1] which ABET regards as an essential part of functioning as part of a team. Others of the new outcomes introduce new elements, such as "a range of audiences," "informed judgments," and "engineering judgment," which are used without definition or explanation. It has been the practice of ABET, when terms are used without definition, to allow programs to define how they are being defined and used in a particular program. Thus, each program should explicitly define, before any assessment is done, how these terms are being used.

While most of the a-k outcomes are found in some form in the new seven outcomes, outcome i), "a recognition of the need for, and an ability to engage in life-long learning,"[2] has been eliminated. Its replacement is outcome 7. This criterion, by requiring student to be able to use appropriate learning strategies, and "acquire and apply new knowledge as needed"[1] captures what some believe is, or should be, the focus of the previous version of the outcome—should ABET be concerned with whether an engineer learns a new language at the age of 70 or that that engineer recognizes that he or she does not have the necessary knowledge to complete an engineering project, and has the skill to acquire and apply that knowledge?

The Assessment Plan and Current Implementation

It is the observation of the author, based on over 20 years of doing ABET evaluation both as a program evaluator for electrical and computer engineering programs, and as an EAC evaluation team chair, that many programs make ABET assessment much more difficult than it needs to be. ABET does not mandate that every course be assessed, or that assessments be done every year, or that outcomes be assessed at multiple levels of learning taxonomies, yet many programs do one or more of these things. ABET only requires that programs clearly demonstrate that by the time of graduation, students have successfully met all learning outcomes. While it is expected that some of the assessments will be objective rather than subjective, and it may be advisable to divide complex outcomes into smaller, more easily measurable, competencies, it is definitely not necessary to measure everything, all the time. This is particularly problematic for smaller programs, where overly extensive assessment processes can become burdensome for faculty and are not sustainable in the long term for that reason.

The assessment committee for the new Computer Engineering program at the University of Tennessee at Chattanooga has constructed an assessment process to evaluate all seven of the new ABET outcomes using only three courses: CPSC 3610, a computer ethics course, which all computer engineering students are required to take, and CPEN 3850 and 4850, the two semesters of the computer engineering capstone sequence. The assessment cycle is two years, with the competencies in 3610 being assessed in school ears ending in odd numbers (e.g., 2016-17) and 3850 and 4850 being assessed in consecutive semesters in school years ending in even numbers. This allows the entire process to be repeated three times in a standard six-year accreditation cycle. Assessing 3850 and 4850 in consecutive semesters is necessary, as for several of the outcomes, a preliminary competency is measured in 3850, and the completion measured in 4850. For example, for outcome 2, the plan states:

- Competency: Students demonstrate the ability to *identify* appropriate realistic constraints, including consideration of health, safety, etc., to the engineering problem for the capstone design
    - Measure: Evaluated in final ENGR 3850 report

- Competency: Students demonstrate ability to generate effective solution(s) to the capstone design problem formulated in ENGR 3850, *including identified constraints*
    - Measure: Evaluated in final ENGR 4850 report

Thus, in order to determine whether students can both identify and apply appropriate standards and constraints, and apply these in an engineering design, it is necessary to evaluate students continuously working on a project; therefore, measuring in sequential semesters is required.

In order to facilitate assessment of outcome 3, the assessment committee has defined "communicate effectively with a range of audiences"[1] to mean oral and written communication with both professors and other students. For outcome 6, the program interprets "engineering judgment" in the context of experimentation as the ability to determine whether the results *make sense* in the context of the experiment and what conclusions can be reasonably drawn from the data.

Each of the competencies making up assessment for an outcome is assessed on a three point scale—"below expectations," "meets expectations," and "exceeds expectations." In each case, "meets expectations" is regarded as the level which would be considered the minimum level of attainment for students to receive a level of C for the given competency on the given assignment. The reports, papers, assignments, etc., used in the assessment are assessed separately for the included competencies, independent of the overall grade on the item. The target for achievement in each case is that 100% of the students who complete the course with the required minimum grade of C will achieve a rating of "meets expectations" or better on each outcome. The rationale for this is that any student who does not make a C will have to repeat the course, and so will have another chance to meet the goal, while any student who successfully completes the course should, at a minimum, achieve a sufficient level of competency on required ABET outcomes. When multiple measures, or multiple sub-competencies, are used on a single outcome, the scores of each are averaged to achieve an overall score. Thus it is possible for students to demonstrate an acceptable level of performance on the overall outcome while failing to meet the level on one or more competencies. However, any sub-competency on which students fail to meet the desired level is flagged, and the instructor is requested to make changes to improve student performance on that element.

As necessary, at the lowest level of competency defined, descriptions are given for each of the three possible performance levels. For example, for a sub-competency of correct referencing for written communication, "exceeds expectations" requires all information to be properly referenced, in an accepted form, with no missing or misplaced information. "Meets expectations" allows some errors in the form of references, e.g., block quotes incorrectly using quotation marks rather than inset, but no unreferenced material. Any unreferenced material is "below expectations."

Which outcomes are measured in which courses is shown in Table 1.

	Outcomes						
	1	**2**	**3**	**4**	**5**	**6**	**7**
CPSC 3610			x	x			x
CPEN 3850	x	x			x	x	x
CPEN 4850	x	x		x	x	x	

Figure 1: Outcomes and Classes Assessed

At the end of each semester in which a course is assessed, the instructor is required to produce a set of electronic files including copies of all student artifacts used in the assessment, course information such as syllabus and course grades, and the instructor's assessment of the competencies being measured in that course, including a discussion of any in which targets are not met. These files are stored on CDs, and are evaluated by the computer engineering assessment committee at the beginning of the following semester.

This process is currently in its second year of implementation: CPSC 3610 was assessed in 2016-17, and CPEN 3850 is being assessed in fall semester 2017; CPEN 4850 will be assessed in Spring 2018, completing the first cycle. At the completion of the cycle, the assessment plan itself will be evaluated, and changes made if necessary to ensure continuous improvement of the program.

Conclusions

While the process described has not yet completed the full cycle, it covers all of the new outcomes in multiple ways, and is very efficient in terms of faculty effort required. This can serve as a pattern for other programs seeking an efficient way to address the new ABET requirements to be ready for an accreditation visit in 2019 or beyond.

References.

1 ABET, "EAC Criterion 3-5 Second Reading Motion," available from http://www.abet.org/wp-content/uploads/2017/09/EAC-Criterion-3-5-Second-Reading-Motion-.pdf, accessed 11/5/17.
2 ABET, "Criteria for Accrediting Engineering Programs: Effective for Reviews During the 2017-18 Accreditation Cycle," Baltimore, MD, October 29, 2016.

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