Most Recent Updates to ABET-EAC-Criteria 3, 4 and 5

Amir Karimi, Randall Manteufel
Mechanical Engineering Department
University of Texas at San Antonio

Abstract

The Engineering Accreditation Commission (EAC) of ABET recently modified criterion 3 (Student Outcome), criterion 4 (Continuous Improvement), and criterion 5 (Curriculum). The revision of these criteria began in 2009 and continued until 2017 when it was finally approved by the Engineering Area Delegation of ABET. The major changes include the replacement of student outcomes a-k by the new outcomes 1-7 for criterion 3, removal of the requirement for evaluation of program educational objectives for criterion 4, and linking of student outcomes to the curriculum for criterion 5. In addition, the definitions of the terminologies used in the general criteria are expanded. The implementation of the new changes began during the 2019-2020 ABET evaluation cycle. This paper is an update of a paper presented in the ASEE-GSW section in 2017 and explains how the proposed changes may affect the ABET-EAC assessment process in criterion 4.

Introduction

All engineering programs requesting accreditation for the first time or seeking re-accreditation by ABET- Engineering Commission's (EAC) are required to demonstrate that the program meets a set of criteria that include both the general criteria for baccalaureate degree programs and the specific program criteria required by the program's lead society (*e.g.*, ASCE, IEEE, ASME, *etc.*).[1] Programs must also meet all the requirements listed in the Accreditation-Policy-and-Procedure-Manual (APPM) of ABET.[2] This paper is an extension of the paper presented and published in the proceedings of ASEE-Gulf Southwest (GSW) section in March 2017.[3] Two similar studies were conducted in 2016 and 2017 which were based on the proposed changes submitted by EAC commission for public comments in 2015 and 2016 respectively.[4,5] The paper published in the proceedings of the 2017 ASEE-GSW section conference summarized the continuous changes made to the ABET-EAC general criteria from 2000 to March, 2017. The minor changes to the ABET-EAC general criteria are briefly highlighted here.

From 2000 to 2008, the ABET-EAC general criteria consisted of the following seven components: (1) Students, (2) Program Educational Objectives (PEO), (3) Program Outcome (PO) and Assessment, (4) Professional Components, (5) Faculty, (6) Facilities, and (7) Institutional Support and Financial Resources. During this period, the assessment and evaluation of PEOs and POs were parts of the requirements of criterion 2 and criterion 3, respectively. Starting with the 2008-09 evaluation cycle, the 7 original components of the general criteria were reorganized into 8 components consisting of: (1) Students, (2) Program Educational Objectives (PEO), (3) Student Outcomes (SO), (4) Continuous Improvement, (5) Curriculum, (6) Faculty,

(7) Facilities, and (8) Institutional Support.[4] The title of Program Outcomes and Professional Components were changed into Student Outcomes (SO) and Curriculum, respectively. The requirements for evaluation of PEOs and POs were removed from criteria 2 and 3 and became a part of the requirement of a new component, Criterion 4-Contineous Improvement. Starting with the 2012-13 evaluation cycle, the requirement of evaluation of PEOs was removed from Criterion 4-Continuous Improvement. Programs were no longer had to evaluate PEOs, but still had to periodically review PEOs to ensure that they remain consistent with the institutional mission, the program's constituents' needs, and the EAC's general criteria.

Revision of Criterion 3 and Criterion 5

In 2009, EAC appointed a task force to start the process of revising Criterion 3. Main motivation for the revision was that very few changes had been made to student outcomes (a-k) since 2000.[6] There was a question whether the SOs a-k were still meeting the original intent. In addition, most citations of shortcomings during the accreditation of programs were related to the assessment of student outcomes. After an exhausting reviewing process that included receiving feedback from appropriate constituencies, the task force identified 75 potential attributes to be considered for the revised list of student outcomes. The potential attributes were grouped into five (5) categories identified as: technical, business, communication, professionalism, and individual skills. During this process it was realized that student outcomes should be tied to criterion 5-Curriculum, hence requiring revision of that criterion also. The EAC Criterion Committee prepared draft versions of revised criterion 3 and criterion 5, which were presented to EAC during the summer commission meeting in July 2014. The EAC members suggested some changes to the draft version and recommended that the committee seek additional comments from the deans, faculty members of engineering programs, and industry. Between July 2014 and May 2015, ABET solicited input from engineering societies, deans, faculty, and industry. Based on the input received, the EAC Criteria Committee made changes to the 2014 draft version of criteria 3 and 5. The updated proposed Criterion 3 and Criterion 5 were presented to EAC again during the summer commission meeting in the July 2015 for approval. After a long discussion, it was decided to table the proposal and place it for public viewing for an additional year. The proposed changes were posted on ABET website for public review and comments with a deadline of June 30, 2016. During the additional period, the engineering educational communities provided many valuable comments for improving the proposed changes. For example during the 2016 ASEE National conference in New Orleans, a town hall meeting was held to discuss the proposed changes to ABET criteria 3 and 5. An ASEE feedback committee had earlier compiled members' input and had posted those comments on the ASEE website.[5, 7] After a short panel presentation by ASEE feedback committee; breakout sessions were formed to discuss the specific areas of interest related to the proposed changes to ABET criteria 3 and 5. Based on the results of the discussion at the town hall meeting, the ASEE feedback committee created a document called "Summary of ASEE Member Views on Proposed Changes to ABET Engineering Accreditation Standards." The document was submitted to ABET-EAC Criteria Committee for consideration.

During 2015-16 public review, the EAC-Criteria Committee received approximately 250 inputs from the public. Based on the inputs received, the committee revised the proposed new Criterion 3 and Criterion 5 and presented them to EAC commissioners during the EAC's summer commission meeting July 2016. After some discussions, few additional changes were made to the proposal. The EAC commission then voted and approved the proposed new criterion 3 and criterion 5 called the "first reading" of these criteria. However, EAC members recommended that the first reading be placed for public review and comments for one more year.

2016 First Reading Proposal and 2017 Final Approval of Criterion 3 and Criterion 5

The first reading of the proposed criterion 3 and criterion 5 was submitted to ABET Engineering Area Delegation (EAD), which has the final approval authority for the approval of proposed changes. The EAC had recommended that the delegation consider another year of public review and comment to ensure all constituents have ample opportunity to consider these latest modifications, and provide any additional comments. The EAD had the following three options: i) approve the proposed criteria as written and implement, ii) delay final approval for one year and seek additional public comment, as recommended by the commission, or iii) reject the proposal. At the end of October 2016, the EAD placed the first reading for public review and comments. After a year of public review of the 2016 first Reading and receiving additional comments, the EAD approved the major parts of the 2016 first reading with minor modifications and additions on October 20 2017. The following sections highlight the new definitions added to the general criteria and changes to Criteria 3 and 5 and explain how these changes might affect the engineering programs.

A new document showing the side by side mapping of the introduction section, definitions, criterion 3, and criterion 5 of the language of the EAC general criteria used for 2018-19 accreditation cycles onto the new language was approved by the EAD became available. The implementation of new changes was scheduled for the 2019-2020 accreditation cycle.[8] The following paragraphs show similar mappings and highlight any changes made to the 2016 first reading during the final approval process.

The first part of the changes to the general criteria deals with definitions. The definitions listed in the new general criteria consist of three categories: those that exited with no changes, those that existed before, but the language is changed in the new general criteria, and those that did not exist before, but added in the new general criteria.

The following definitions exited in previous EAC general criterion applicable to 2017-18 and 2018-19 accreditation cycles with no change of terminology in the new general criteria.

- **Program Educational Objectives**-Program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. Program educational objectives are based on the needs of the program's constituencies.

- **Student Outcomes** – Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program.

- **Assessment** – Assessment is one or more processes that identify, collect, and prepare data to evaluate the attainment of student outcomes. Effective assessment uses relevant direct, indirect, quantitative and qualitative measures as appropriate to the outcome being measured. Appropriate sampling methods may be used as part of an assessment process.

- **Evaluation** – Evaluation is one or more processes for interpreting the data and evidence accumulated through assessment processes. Evaluation determines the extent to which student outcomes are being attained. Evaluation results in decisions and actions regarding program improvement.

Tables 1 through 6 compare the changes in terminologies related to criterion 5. They compare the definitions used during the 2017-18 and 2018-19 accreditation cycles with those implemented during the 2019-20 accreditation cycles. They list also include new definitions that did not exist in the general criteria for the previous accreditation cycles. The tables also highlight any changes occurred from the 2016 first reading proposal until the final approval in October 2017.

Table. 1 Mapping of the definition for Basic Science

Basic Science	
EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles	**2016 first reading proposal and approved by EAC without any changes. Applicable beginning in the 2019-20 accreditation cycle**
Imbedded in Criterion 5: Basic sciences are defined as biological, chemical, and physical sciences.	Basic sciences are disciplines focused on knowledge or understanding of the fundamental aspects of natural phenomena. Basic sciences consist of chemistry, physics, and other natural sciences including life, earth, and space sciences.

Table 2. New definition for College Level Mathematics

College-Level Mathematics	
EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles	**2016 first reading proposal and approved by EAC without any changes. Applicable beginning in the 2019-20 accreditation cycle**
Not explicitly defined, but it was understood that it must be above pre-calculus	College-level mathematics consists of mathematics that requires a degree of mathematical sophistication at least equivalent to that of introductory calculus. For illustrative purposes, some examples of college-level mathematics include calculus, differential equations, probability, statistics, linear algebra, and discrete mathematics

Table 3. New definition for Complex Engineering problem

College-Level Mathematics	
EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles and 2016 first reading proposal	**Added after 2016 first reading proposal. Applicable beginning in the 2019-20 accreditation cycle**
Not defined.	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.

Table 4. Mapping of definition for Engineering Science

Engineering Science	
EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles	**2016 first reading proposal and approved by EAC without any change. Applicable beginning in the 2019-20 accreditation cycle**
Imbedded in Criterion 5: 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 sciences are based on mathematics and basic sciences but carry knowledge further toward creative application needed to solve engineering problems. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other.

Table 5. Comparison of definition for Engineering Design

Engineering Design	
EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles	**2016 first reading proposal and approved by EAC with minor changes (underlined). Applicable beginning in the 2019-20 accreditation cycle**
Imbedded in Criteria 3 and 5: Criterion 3. … within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability Criterion 5: Engineering design is	Engineering design is the 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. ~~The process~~ Engineering design involves identifying opportunities, developing requirements, performing analysis and synthesis,

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.	generating multiple solutions, evaluating ~~those~~ solutions against requirements, considering risks, and making trade-offs, for ~~to identify~~ the purpose of obtaining a high quality solution under the given circumstances. For illustrative purposes only, examples of possible constraints include accessibility, aesthetics, codes, constructability, cost, ergonomics, functionality, interoperability, legal considerations, maintainability, manufacturability, marketability, policy, regulations, schedule, standards, sustainability, or usability.

Table 6. New definition for Team

Team	
EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles	**2016 first reading proposal and approved by EAC some changes (underlined). Applicable beginning in the 2019-20 accreditation cycle**
No definition	A team consists of more than one person working toward a common goal and should include individuals of diverse backgrounds, skills, or perspectives ~~consistent with ABET's policies and positions on diversity and inclusion~~.

The new EAC general criteria contains only seven outcomes associated with Criterion 3-Student Outcomes as compared to the 11 outcomes (a-k) in the previous Criterion 3. Some of the current student outcomes are moved into the requirements of the Criterion 5 in the new general criteria Table 7 shows the changes in the lead statement from old Criterion 3 to new Criterion 3.

Table 7. Change of opening statements for Criterion 3

EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles	**2016 first reading proposal and approved by EAC without any changes. Applicable beginning in the 2019-20 accreditation cycle**
The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.	The program must have documented student outcomes that support the program educational objectives. Attainment of these outcomes prepares graduates to enter the professional practice of engineering. Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.

Tables 8 shows the equivalencies of current student outcomes (a) through (k) with the seven student outcomes listed in the Criterion 3. Note that the previous student outcomes (a) and (e) are combined into a single student outcome (1) in the new criterion 3. Student outcome (b) in the previous criterion 3 is equivalent to student outcome (6) in the new criterion3, except that the wording in the statement has been changed to remove some of the confusions. The ability to design of experiment interpreted differently by various programs. A search on the Internet for "design of experiment" results in several different definitions. The proposed change of wording to "an ability to develop appropriate experimentation," makes it more clear that student not only have to be able to conduct experiment following a given procedure, but they also have to be able to develop experimentation on their own for a specific purpose. The statement for the student outcome (c) is very similar to student outcome (2), except that the "manufacturability, and sustainability" requirements of the previous outcome now is included in the new definition of engineering design. Student outcome (d) is reworded and is presented as student outcome (5) in the new criterion 3. The statements for SOs (f), (h), (j) in the previous criterion 3 are rewarded and presented as SO (4) in the new criterion 3. Student outcome (g) from previous criterion 3 is presented as SO (3) in the new criterion 3. Student outcome (i) from previous criterion 3 is presented as the new SO (7) in the new criterion. There is no direct equivalence for student outcome (k) in the new criterion 3, but it is implied in SOs (1), (2), 6), and Criterion 5 (b).

Table 8. Equivalencies of student outcomes in the previous and the new criterion 3

EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles	**2016 first reading proposal and approved by EAC with some changes (underlined). Applicable beginning in the 2019-20 accreditation cycle**
(a) an ability to apply knowledge of mathematics, science, and engineering (e) an ability to identify, formulate, and solve engineering problems	1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	2. an ability to apply the engineering design ~~process~~ to produce solutions that meet specified needs with consideration ~~for~~ of public health, ~~and~~ safety, and welfare, as well as global, cultural, social, environmental, economic, and economic factors. ~~other factors as appropriate to the discipline~~
(g) an ability to communicate effectively	3. an ability to communicate effectively with a range of audiences
(f) an understanding of professional and ethical responsibility (h) the broad education necessary to understand the impact of engineering solutions in a global, economic,	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 context (j) a knowledge of contemporary issues	environmental, and societal contexts
(d) an ability to function on multidisciplinary teams	5. an ability to function effectively on a team whose members together provide leadership, ~~as a member or leader of a team that establishes goals, plans tasks, meets deadlines, and~~ creates a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
(i) a recognition of the need for, and an ability to engage in life-long learning	7. an ability ~~to recognize the ongoing need~~ to acquire new knowledge as needed, ~~to choose~~ using appropriate learning strategies~~,~~ ~~and to apply this knowledge~~.
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Implied in SOs 1, 2, 6 and included as a part of art Criterion 5 (b)

Table 9 compares the requirements of the past criterion 5 with those included in the new criterion 5. In the previous requirements one year was defined as 32 semester credit hours for programs requiring 128 semester credit hours or more for the degree, or 25% of total semester hours required for the degree if it was less than 128 hours. In the new Criterion 5 one year is defined as 30 hours (120 hours/4 years) regardless of the total number of hours required for the degree.

Table 9. Comparison of the current requirements of criterion 5 with those for the 2016 proposal

EAC Criteria effective in 2017-18 and 2018-19 accreditation cycles	**2016 first reading proposal and approved by EAC with minor changes (underlined). Applicable beginning in the 2019-20 accreditation cycle**
a. one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline	a. a minimum of 30 semester credit hours (or equivalent) of a combination of college-level mathematics and basic sciences with experimental experience appropriate to the program
b. one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study	b. a minimum of 45 semester credit hours (or equivalent) of engineering topics appropriate to the program, consisting of engineering sciences and engineering design, and utilizing modern engineering tools (SO k)

c. a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives	c. a broad education component that complements the technical content of the curriculum and is consistent with the program educational objectives
d. a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints	d. a culminating major engineering design experience ~~based on the knowledge and skills acquired in earlier course work~~ that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work.

Effects of Expansion of Definitions and Changes in the New General Criteria on Assessment Process

Criteria 2, 3, and 4 have been the most often cited criteria during the past accreditation cycles. One important part of the new general criteria approved in October 2017 is added and expanded definitions. Overall, many of the old definitions are now longer, which may alleviate some of the difficulties programs had in understanding the intent of the criteria's requirements. The definition of "Basic Science" is expanded to clarify that it includes chemistry, physics, and natural sciences (life, earth, space). "Mathematics" is defined more clearly in the new general criteria and a list of specific courses such as calculus, differential equations, probability, statistics, linear algebra, and discrete mathematics are given as examples. The definition of "Engineering Design" is vastly expanded that broadens the definition of the design process to include synthesis and analysis under a broad set of illustrative constraints such as accessibility, aesthetics, codes, constructability, cost, ergonomics, extensibility, functionality, interoperability, legal considerations, maintainability, manufacturability, marketability, policy, regulations, schedule, standards, sustainability, or usability. "Team" is now defined as a group of students that "consists of more than one person working toward a common goal and should include individuals of diverse backgrounds, skills, or perspectives. The addition and expansion of these definitions helps to make the content of criteria 3 and 5 more clear. However, the evaluation of some components of the new general criteria is still subject to interpretation by the engineering programs and the members of the ABET program evaluation teams.

Some of the materials in the following statements are taken directly from topics available on the ABET website[9,10] and presented here in a single document. It should be noted that in the new general criteria, new requirement is added to Criterion 2-PEOs. Criterion 2 now requires a documented process for the periodic review and updating of PEOs. For Criteria 3 programs must show how SOs prepare graduates to attain the PEOs. Criterion 4 requires that "the program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained." It is important that programs evaluate the extent to which graduates collectively have attained each SO by the time of graduation. It is not necessary to assess the level of attainment for an outcome for each individual graduate, but an appropriate statistical sampling process may be used in the assessment of outcomes. In addition, the meaning of level attainment in not defined in the general criteria. Therefore, it is important that the programs define the “level of attainment” in their assessment process. It is not required that all outcomes to be attained to the same degree or a numerical scale to be used to measure the degree of attainment. However, the program must still convince the evaluation team that the graduates achieve the levels of attainment defined by the program for each outcome, collectively. Criterion 4 also requires that the results of SO evaluations must be systematically utilized as input for the continuous improvement of the program. Therefore, the programs must show that the results of the evaluations of SOs are systematically used as input for the continuous improvement of the program. ABET’s currently provides the following instructions to the Program Evaluators PEVs. Not all assessment data have to be objective or direct; some assessment data can be subjective or indirect. However, the evaluation of a SO cannot be based only on subjective evaluation. Therefor the results of student survey cannot be used alone for the evaluation of one of the SOs. The evidence for each SO does not have to in the form of work that students have produced but the programs must convince the members of ABET visiting team that the extent to which student outcomes are attained has been met. Since the acceptance of the attainments of a SOs in such cases is subject to interpretation by the members of the ABET program evaluation team, we recommend that it is always safer to use students work as evidence for the majority of outcomes.

When a program is going to be visited in 2020-21 and has only one year of data related to the new outcomes and older data from the (a)-(k) outcomes, “it is not necessary to aggregate data from student outcomes (a)-(k) and (1)-(7), unless the program finds the aggregation to be useful. Presumably, the program has followed its continuous improvement process for the five prior years and has evidence of the degree to which outcomes (a)-(k) were obtained during that period, and how that assessment data was used as input to the program's continuous improvement process. PEVs will expect to see the plans for assessing and evaluating attainment of student outcomes (1)-(7) and implementation of these plans as much as practical, including the assessment data collected for (1)-(7), the degree to which (1)-(7) have been attained, and the manner in which evaluations of the assessment data have been used as input to the continuous improvement process.”[10]

Programs should pay attention to the following elements in Criterion 3:[10]

- “SO1 requires that students have the ability to solve **complex** problems. Programs will want to ensure that their problems are complex as defined in the new general criteria. “
- “SO2 requires that students have the 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. This does not mean that each of these elements must have a significant effect on the design - it just means that the program must show that students **consider** these elements as they engage in design.” We recommend that programs require students to include sub-headings in their project reports for the elements that must be considered in the design project.
- “SO3 requires that students have the ability to communicate with a range of audiences. It is the program's responsibility to determine the range of audiences. For example, if a

program stresses preparing students for graduate school, it might have students prepare a journal paper. There are many other possible audiences: faculty, students, non-technical, the public sector, etc. For example, students in biomedical engineering programs might communicate with physicians, nurses, or other medical personnel. In the major design experience, students might communicate with external clients. It is the program's responsibility to determine the most meaningful audiences for its students."

- "SO4 requires in part that students have the ability to make informed judgments that consider the impact of engineering solutions in global, economic, environmental, and societal contexts. It is not necessary for every engineering situation to require that each of these contexts be a major consideration. **Consideration** of the impact as the judgment is made is key."
- "SO5 requires that students be able to function effectively on collaborative and inclusive teams as well as carry out project management tasks. Programs have a variety of methods to develop and assess these abilities. There are many texts on project management available for use. Gantt charts, schedules, scrum, goal setting, and decision matrices might be useful as project management tools and techniques. Inclusiveness and collaboration can be characterized using existing instruments in the literature."
- "SO6 requires in part that students have the ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. There is no requirement that students be able to design an experiment." However, this still requires an open-ended experimentation project that students have to select right apparatus, develop procedure to conduct appropriate experiment, collect data, and use engineering judgment to draw conclusions.
- "SO7 requires that students be able to acquire and apply new knowledge as needed, using appropriate learning strategies. The ABET Industrial Advisory Council indicated that it is important for students to take responsibility for their own learning. There are many ways a student can demonstrate this ability. For example, students could engage in such activities as identifying needed information for a project, examining sources for the information, determining an appropriate source and applying the information."

Engineering programs can still employ their previous instruments used for the assessment and evaluation of SOs (A-k) or modify them to assess and evaluate the student outcomes in the new general criteria. Most programs have been using the results of student performance on specific problems, laboratory experiments, design projects, or other types of reports as primary direct measurement for assessing student outcomes. Other instruments such as results of the fundamentals of engineering (FE) exam and student surveys are used as secondary instruments for the assessment of student outcomes. Most programs have been using the same instruments for the assessment of both student outcomes (a) and (e). Since the SO1 is a combination of outcomes (a) and (e), programs can continue using the same instruments as before. For assessment of SO2, programs can still use the same instruments as they were previously using for SO (c). For assessment of SO6, again programs can still use the same instruments as they were previously using for SO (b). The SO3, an ability to communicate effectively with a range of audiences, replaces SO (g), an ability to communicate effectively. The phrase "with a range of audiences" can be subject to interpretation. It can be assumed that each program can define the range of audiences as groups of students, faculty, industrial advisory board members, etc. For assessments of SO4 "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," the same instruments previously utilized for the assessment of SO (f), SO (h), and SO (j) may be used. It is expected that programs assess the ability of students to consider all impacts listed in SO4 “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.” This might not be achievable in a single course. Programs may have to select two or three courses in the curriculum to demonstrate the attainment of this outcome. SO5 replaces SO (d). The word “multidisciplinary teams” in SO (d), “an ability to function on multidisciplinary teams” interpreted differently by different people. It was not quite clear if a multidisciplinary team should be composed of students from various colleges, students from various engineering programs, or simply a diverse group of students from the same program. SO5, “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” requires a more complex assessment process. First, the new definition of “Team” requires that a team should consist of more than one person working toward a common goal and should include individuals of diverse backgrounds, skills, or perspectives. Therefore, programs must demonstrate that the definition of Team requirements are met. SO5 requires that members of a team must be able to create a collaborative and inclusive environment. Several methods for measuring attainment of this ability have been used by programs:[10]

“a. Videotaping a team meeting and evaluating the team performance using a rubric.
b. Students write descriptions of their contributions and their team members' contributions indicating how they collaborated and were inclusive. A rubric is often used to evaluate the description.
c. External clients meet with students over a period of time and evaluate their contributions and inclusiveness.
d. Use of web-based peer evaluations such as CATME.org or TEAMMATES. The peer evaluations include specific questions about collaboration and inclusiveness.
e. Verbal feedback from course TAs or instructors about a team's collaboration and inclusiveness. Students take notes and give evidence to support or refute the feedback.”

Instruments previously used for the assessment of SO (i) can still be employed for SO7.

If student work in a course shared by two or more programs used for attainment of a given SO, then each program has to conduct a separate assessment to demonstrate the attainment of that SO for graduates of the respective program. For example, if a course in Statics is selected to demonstrate the attainment of SO-1 by both Civil Engineering and Mechanical Engineering programs and students of both programs are enrolled in the same section of a Statics course, then student performance data used for assessment must be segregated for each program. The Civil Engineering program must use the data for the students in the Civil Engineering program only and the Mechanical Engineering program must do the same thing for the mechanical engineering program. Therefore, it might be preferable not to select such courses in the assessment process.

Criterion 5-Curriculum requires a combination of one year of college level mathematics and basic sciences. It also required one and half years of engineering sciences and engineering design. One year of academic year was not defined in the past, but in the self-study template, one academic year was defined as 32 semester credit hours (SCH) or 25% of the total credit hours required for the degree. In the new Criterion 5, the requirements are listed as a minimum of 30 SCH (or equivalent) of combination of college level mathematics and basic sciences as well as a minimum of 45 SCH (or equivalent) of engineering topics, consisting of engineering sciences and engineering design.

Criterion 5 (b) requires the curriculum to include "a minimum of 45 semester credit hours (or equivalent) of engineering topics appropriate to the program, consisting of engineering and computer sciences and engineering design, and utilizing modern engineering tools." For clarity, this statement does not require a course in the curriculum explicitly titled "computer science." course. The intent of this language is to make clear that the current engineering criteria consider computer science and computing to be engineering topics rather than basic science.[10] All current engineering programs incorporate computer/computing sciences in some form or another in their curriculum.

Conclusions

ABET has produced significant guidance for programs on how to understand and adjust to changes in criterions 3, 4 and 5. Changes in criterion 3 include the revised SO which is integral to a programs continuous improvement in criterion 4. Some of the SO are slightly more challenging since many SO are multifaceted. The new SO#1 is not just equivalent to the previous SO "a", but includes the previous "e" since it has the idea of complex problems. Hence, the previous assessment tools of "e" need to be used for SO#1, not just tools from "a". SO#5 is much more detailed than the previous SO "d" in that teams the emphasis is on more autonomous teams with responsibility for goals, tasks and objectives. Previously in SO "b" there was the expectation that students design as well as conduct experiments. In SO#6, the emphasis on design has been replaced by increased emphasis on engineering judgment to draw conclusions from experiments. SO#7 is a revision of previous SO "i" dealing with life-long learning. The wording and nuanced emphasis is more on being able to acquire new knowledge, which appears more amenable to assessment than the previous "engage in life-long learning". The previous SO "k" dealing with modern engineering tools is distributed to SOs as well as criterion 5(b). The tools and metrics used to assess the old SO appear to be very similar to those needed for the revised SO. A mechanical engineering program will need to understand these changes when they complete their self-study report in the next accreditation cycle.

References

1. URL:https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2020-2021/
2. URL: https://www.abet.org/accreditation/accreditation-criteria/accreditation-policy-and-procedure-manual-appm-2020-2021/
3. Karimi A., 2017, "How the Proposed Changes in ABET-EAC-Criteria 3 and 5 Effects Assessment Process?" *Proceedings of the* 2017*- ASEE-GSW Section Conference,* Paper ID # 111, March 12-14, 2017, Dallas, Texas

4. Barr, R.E., 2016, “Proposed Changes to ABET Criteria 3 and 5,” *Proceedings of 2016 ASEE-GSW Section Conference*, Paper ID # 103, March 6-8, 2016, Fort Worth, Texas
5. Barr, R.E., 2017, “An ABET Preparation Perspective Under the New Proposed Criteria 3 and 5,” *Proceedings of 2017 ASEE-GSW Section Conference*, Paper ID #20, March 12-14, 2017, Dallas, Texas
6. URL: *http://www.abet.org/rationale-for-revising-criteria-3-and-5/*
7. URL: https://aseetownhall.wordpress.com/2016-town-hall/
8. URL https://www.abet.org/wp-content/uploads/2018/03/C3_C5_mapping_SEC_1-13-2018.pdf
9. URL: https://www.abet.org/
10. URL: https://www.abet.org/wp-content/uploads/2019/04/FAQs-for-EAC-C3-C5-4-8-2019.pdf.

AMIR KARIMI
Amir Karimi, University of Texas, San Antonio Amir Karimi is a Professor of Mechanical Engineering at The University of Texas at San Antonio (UTSA). He received his Ph.D. degree in Mechanical Engineering from the University of Kentucky in 1982. His teaching and research interests are in thermal sciences. He has served as the Chair of Mechanical Engineering (1987 to 1992 and September 1998 to January of 2003), College of Engineering Associate Dean of Academic Affairs (Jan. 2003-April 2006), and the Associate Dean of Undergraduate Studies (April 2006-September 2013). Dr. Karimi is a Fellow of ASEE, a Fellow of ASME, senior member of AIAA, and holds membership in ASHRAE, and Sigma Xi. He has served as the ASEE Campus Representative at UTSA, ASEE-GSW Section Campus Representative, and served as the Chair of ASEE Zone III (2005-07). He chaired the ASEE-GSW section during the 1996-97 academic year.

F RANDALL D. MANTEUFEL
Dr. Randall Manteufel is an Associate Professor of Mechanical Engineering at The University of Texas at San Antonio (UTSA). He has won several teaching awards, including the 2012 University of Texas System Regent’s Outstanding Teaching Award and the 2013 UTSA President’s Distinguished Achievement Award for Teaching Excellence, the 2010, 2014, 2018 and 2019 College of Engineering Student Council Professor of the Year Award, 2008 Excellence in Teaching Award for College of Engineering, and 2004-2005 Mechanical Engineering Instructor of the year award, 1999 ASEE-GSW Outstanding New Faculty Award. Dr. Manteufel is a Fellow of ASME with teaching and research interests in the thermal sciences. In 2015-2016, he chaired the American Society for Engineering Education Gulf Southwest section and in 2018-2019 he chaired the Academy of Distinguished Teaching Scholars at UTSA. He is a registered Professional Engineer in Texas.