Forum on Proposed Revisions to ABET Engineering Accreditation Commission General Criteria on Student Outcomes and Curriculum (Criteria 3 and 5): A Workshop Summary

DETAILS

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AUTHORS

Robert Pool, Rapporteur; Committee on Engaging the Engineering Community in a Constructive Dialogue Regarding ABET Criteria Changes; National Academy of Engineering

FORUM ON PROPOSED REVISIONS TO ABET ENGINEERING ACCREDITATION COMMISSION GENERAL CRITERIA ON STUDENT OUTCOMES AND CURRICULUM (CRITERIA 3 AND 5): A WORKSHOP SUMMARY

Robert Pool, Rapporteur

Committee on Engaging the Engineering Community in a Constructive Dialogue Regarding ABET Criteria Changes

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Committee Members[1]

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Wayne Bergstrom
2015-2016 President-Elect
Accreditation Board for Engineering and Technology

Principal Engineer
Bechtel Infrastructure and Power Corporation

Mary Boyce (NAE)
Dean of Engineering
The Fu Foundation School of Engineering and Applied Science
Columbia University

Norman Fortenberry
Executive Director
American Society for Engineering Education

Karan Watson
Provost and Executive Vice President
Texas A&M University

National Academy of Engineering Staff

Proctor Reid
Director of the Program Office

Catherine Didion
Senior Program Officer (until January 2016)

Amelia Greer
Associate Program Officer (until April 2016)

Carl Anderson
Program Coordinator

[1] The planning committee was solely responsible for organizing the workshop, identifying topics, and choosing speakers. The responsibility for the published workshop summary rests with the rapporteur and the institution.

Acknowledgment of Reviewers

The summary of this publication has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies of Sciences, Engineering, and Medicine. The purpose of this independent review is to provide candid and critical comments to assist the NAE in making its published workshop summary as sound as possible and to ensure that the manuscript meets institutional standards for objectivity, evidence, and responsiveness to the project's charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We thank the following individuals for their review of the workshop summary:

Nadine Aubry, Northeastern University

Kenneth Ball, George Mason University

Dianne Chong, The Boeing Company (ret.)

Norman Fortenberry, American Society for Engineering Education

Enrique Lavernia, University of California, Irvine

Dean Nieusma, Rensselaer Polytechnic Institute

Karan Watson, Texas A&M University

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the views expressed in the summary, nor did they see the final draft of the summary before its release. The review of this publication was overseen by **Al Romig**, Executive Officer of the NAE. He was responsible for making certain that an independent examination of this manuscript was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this publication rests entirely with the rapporteur and the National Academy of Engineering.

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Introduction

On February 16, 2016, the National Academy of Engineering held a forum to discuss proposed changes to criteria used by ABET (formerly the Accreditation Board for Engineering and Technology) to accredit engineering programs in colleges and universities around the world. The Forum on Proposed Revisions to ABET Engineering Accreditation Commission General Criteria on Student Outcomes and Curriculum (Criteria 3 and 5) convened a variety of stakeholders in the education of engineers, including representatives of universities, industry, and professional organizations. The presenters and attendees discussed the proposed changes and related issues such as a perceived lack of communication surrounding the development of the proposed changes and the degree to which the criteria prepare engineering students for jobs after graduation. The forum agenda is **appendix A**, the ABET Criteria for Accrediting Engineering Programs, 2016–2017, excluding program-specific criteria, are in **appendix B**, and the proposed revisions are detailed in **appendix C**.

This summary of the forum presentations and discussions reflects only the opinions of those who spoke at the workshop. This summary has been prepared by the workshop rapporteur as a factual summary of what occurred at the workshop; it offers no conclusions or recommendations. The planning committee's role was limited to planning and convening the workshop. The views contained in the report are those of individual workshop participants and do not necessarily represent the views of all workshop participants, the planning committee, or the National Academy of Engineering.

Chapter 1 provides background and the context for the forum, including concerns expressed at the forum about a perceived lack of communication between ABET and the engineering education community. **Chapter 2** reports comments on two broader aspects of the proposed ABET criteria, definitions of terminology and the overall requirements for an engineering degree. **Chapter 3** summarizes discussions about the connection between the ABET criteria and how well prepared graduating engineering students are for a career in engineering, touching on industry needs, lifelong learning, and licensing. **Chapter 4** looks at nontechnical aspects of an engineering education, such as the requirements for a "broad" or "general" education, multidisciplinary teams, and the importance of diversity. **Chapter 5** briefly reviews the next steps in the process that will potentially lead to a revised set of ABET criteria.

Chapter 1
Background

ABET accredits programs in engineering, engineering technology, applied science, and computing at colleges and universities around the world. As Joe Sussman, the organization's chief accreditation and information officer, explained, ABET's accreditation of a program is intended to indicate to potential employers and others that students graduating from that program have received an education that meets certain quality standards and prepares them for a career in their profession. ABET accredits programs; it does not certify institutions, students, degrees, or facilities.

ABET is a nongovernmental federation of 35 member societies, including the American Institute of Aeronautics and Astronautics, American Institute of Chemical Engineers, American Society of Civil Engineers, IEEE, and American Society for Engineering Education. The member societies develop program criteria, appoint the board of delegates, nominate members to the four accreditation commissions (in applied science, computing, engineering, and engineering technology) that carry out the accreditation process, and recruit and assign program evaluators. ABET's work is done by more than 2,000 volunteers from the member societies.

ABET accreditation is voluntary, and as of October 1, 2015, ABET had accredited more than 3,600 programs at 741 institutions in 29 countries. The accreditation process, which generally takes 18–21 months, involves both a self-study report and program evaluators from outside the institution.

There are eight criteria for ABET accreditation of an engineering program[1]:

- Criterion 1 concerns students, specifically monitoring to foster their success, assessment of their progress and performance, admission procedures, assignment of academic credit, and other related issues.
- Criterion 2 concerns the program's educational objectives, which must be consistent with the ABET criteria. Program educational objectives define what the graduate is expected to be able to do 3–5 years after graduation.
- Criterion 3 concerns student outcomes, such as the abilities to apply knowledge of mathematics, science, and engineering; to design a system within economic, social, ethical, global, and other constraints; to function on multidisciplinary teams; to recognize of life-long learning and contemporary issues; and to communicate effectively.
- Criterion 4 concerns institutional quality management systems and how they assess whether and to what degree programs succeed in accomplishing stated learning outcomes.
- Criterion 5 specifies curricula: An engineering degree program must include, for example, 1 year of mathematics and basic sciences; 1½ years of various engineering topics, including design and practical

[1] Effective at the time of the forum discussions, the Criteria for Accrediting Engineering Programs: Effective for Reviews During the 2015–2016 Accreditation Cycle (approved November 1, 2014) are available on the ABET website, www.abet.org, under Accreditation Criteria and Supporting Docs. The proposed changes are also posted there under Criteria for Accrediting Engineering Programs, 2016–2017. This document, excluding specific program criteria, is included as appendix C of this summary.

application; a culminating design project; and a general education component that is consistent with the program's educational objectives.

- Criterion 6 concerns faculty numbers, qualifications, and competence; interactions with students as well as industrial and professional practitioners; and professional development.
- Criterion 7 concerns facilities, including laboratories, equipment, resources, and supporting infrastructure.
- Criterion 8 concerns institutional support such as funding and staffing to ensure the quality and continuity of the program.

There is a process for making changes to any of the criteria, Sussman explained. Proposals for modifying criteria can come from a variety of places, but most commonly originate with the member societies. ABET's Engineering Accreditation Commission (EAC) is responsible for considering proposed changes to the criteria for engineering programs and deciding on their disposition.

Consideration of a proposal starts with the EAC Criteria Committee, which makes recommendations to the EAC. If the EAC approves a proposed change, it sends the proposed amendment to the relevant Area Delegation (representing the member professional societies in the same four areas as the commissions) for a "first reading." The Area Delegation can reject the proposal, ask the EAC to work on it further, or approve the proposal and release it for a period of public review and comment.

If the proposed changes are released for comment, the Criteria Committee is responsible for reviewing the comments and deciding whether the changes should be modified. Then the proposed changes, whether or not revised by the Criteria Committee, are sent back to the EAC, which also reviews the comments and decides whether further changes should be made. Next, the proposed changes are sent to the Area Delegation for a "second reading." The delegation can reject the proposed changes, ask for more work on them, or approve them and determine a phase-in period during which the changes will be adopted in the accreditation criteria.

The Proposed Changes

The current version of the ABET engineering criteria, instituted in 2000, is known as EC2000. Several speakers observed that EC2000 represented a major philosophical shift from the previous criteria. Mickey Wilhelm, dean emeritus at the Speed School of Engineering at the University of Louisville and a member of the ABET board of directors, noted that before EC2000, ABET focused on ensuring that graduates of a program were following the published curriculum. In Wilhelm's view, EC2000 shifted the focus to student outcomes—what the students had learned and whether that learning prepared them to enter the engineering workforce. Sussman reported widespread national and international acceptance of the new approach and of the new criteria of the EC2000.

The proposed changes now under consideration (see appendix C) had their roots in discussions that took place in 2009, said Patricia Brackin (Rose-Hulman Institute of Technology), current chair of the EAC Criteria Committee. At that point, the EAC was receiving requests from member societies to look at the student outcomes, labeled (a) through (k), in Criterion 3, and to consider adding new criteria.

BACKGROUND

According to Phillip Borrowman (Hanson Professional Services), a past president of ABET, the premise that the EAC used to decide to review the criteria was that academic constituents were having difficulty assessing some of the student outcomes and as a result were receiving a substantial number of shortcomings during accreditation reviews. However, he noted that this premise bothered him because reviewing the criteria for changes to make it easier for programs to meet them did not seem like a reasonable justification. In fact, according to Borrowman, the EAC accredits almost every program it evaluates: if all programs are meeting the criteria, it was unclear to Borrowman why a review of the criteria based on the given premise was considered.

The EAC recognized that many of the shortcomings reported each year concerning the criteria were related to Criterion 3 and so decided to reexamine that criterion. The Criteria Committee went through a multistep process, identifying the key stakeholders, reviewing correspondence received about Criterion 3, and conducting an in-depth literature review. According to Brackin, this literature review included (but was not limited to) the following works: Engineering Change: A Study of the Impact of EC2000 (ABET, 2006), Civil Engineering Body of Knowledge for the 21st Century (ASCE, 2008), Vision 2030 Reveals Workforce Development Needs (ASME, 2011), The Roadmap to 21st Century Engineering (Duderstadt, 2008), Attributes of a Global Engineer: Findings from a Work-in-Progress International Survey (Hundley, 2011), Graduate Attributes and Professional Competencies: Comparisons of the Washington Accord, Sydney Accord, and Dublin Accord (International Engineering Alliance, 2009), Graduate Attributes and Professional Competencies; Version 3 (International Engineering Alliance, 2013), Rising Above the Gathering Storm, Revisited (National Academies, 2010), Educating the Engineer of 2020: Adapting Engineering Education to the New Century (National Academy of Engineering, 2005), and Position Statement No. 1752 on Engineering Education Outcomes (NSPE, 2010).

A task force assembled to review Criterion 3 determined that all 11 of the outcomes had at least mild shortcomings and that five of them—(d), (f), (h), (i), and (j)—had proved difficult to assess. As the task force members investigated the problems with the outcomes, they spoke with assessment experts who identified two concerns: use of the word "understand" in the outcomes and of "contemporary issues" in the criteria. Brackin reported confusion over the meaning of the latter, in terms of how broadly contemporary issues could be defined.

The task force concluded that the student outcome criteria had a number of problems that needed to be addressed. Some of the criteria were interdependent, some were too broad, and others were too vague.

Having reached this conclusion, the task force began to communicate with constituent groups and to solicit suggestions about how the criteria might be revised beginning in 2012–2013. The commission received proposals from constituent groups for additional student outcomes. The proposed additions brought the total number of student outcomes under consideration to 75. The task force grouped these suggested outcomes in six categories. The task force presented their findings to the full EAC in July 2013, at which time the work of the task force was transferred to the EAC Criteria Committee.

In July 2014, before a first reading, the Criteria Committee chose to send the proposed new categories out to constituent groups for feedback, and received more than 100 comments from member society committees and individuals. Based on this feedback, the Criteria Committee added a seventh category to the list of student outcomes, resulting in seven topic areas:

1. engineering problem solving,
2. engineering design,
3. measurement, testing, and quality assurance,
4. communication skills,
5. professional responsibility,
6. professional growth, and
7. teamwork and project management.

Brackin noted that the topic area added during this phase of the process was number 6, professional growth. This was largely due, she said, to the importance the Industrial Advisory Board placed on lifelong learning in their comments.

During the process, Brackin said, it became clear that some elements of Criterion 3 would more properly fit in Criterion 5, because much of Criterion 5 focuses on the definition or explanation of key terms. Because Criterion 3 assumes and uses those definitions, the committee proposed modifications to Criterion 5 as well. In addition, for the same reason, revisions were proposed to the introductory section, following the harmonized ABET definitions.

Communication about the Proposed Changes

A number of forum participants said they felt that there had been a lack of communication about the proposed criteria changes and that a number of important stakeholders had not been informed of them until the process was far along. Several participants noted that concern about communication was one of the factors behind the decision to hold the NAE forum.

Donna Riley (Virginia Tech), a former program director for engineering education at the National Science Foundation (NSF), described a June 2015 letter to ABET about the proposed changes that was signed by 346 people from the engineering and education community, including 99 deans and associate deans. The letter had its origins in a session at the June 2015 annual meeting of the American Society for Engineering Education (ASEE), which Riley said was the first time many of the people at that meeting learned about the proposed changes.

The letter suggested that the process of developing and approving the changes be slowed down and the timeline extended to allow for input to be received from additional professional societies, deans, faculty, and industry stakeholders. In particular, it requested that the first reading of the proposed criteria, which the authors understood to be scheduled for July 2015, be delayed. (The first reading took place in October, 2015.)

Gerry Holder (University of Pittsburgh) reported on his perception of ABET's response to the letter. Authored by past president Jamie Rogers and executive director Michael Milligan, the response said that if the EAC were to pass any proposed revision of Criterion 3 and Criterion 5, the ABET Board of Delegates would have to review and approve the proposal at first reading and that this step could not possibly happen before October 2015. Furthermore, the response said, even if it did, it was likely that the board would release the proposed criteria for two years of public review and comment. However, Holder noted, the review and comment period would last only eight months, ending in June, 2016.

Patricia Daniels (University of Washington), who has worked extensively with ABET, explained that after getting feedback from the community, the EAC had produced a document that its members thought was much improved. At that point the Criteria Committee asked that the revised proposed changes be sent officially to the Engineering Area Delegation for the first reading and also be sent out again for public comment. Once the Criteria Committee receives the next round of feedback from NAE forum attendees and others, Daniels noted, it is likely to make additional changes in the criteria.

Chapter 2
General Issues

In addition to the focus on specific details of the proposed changes to student outcomes and curriculum in Criteria 3 and 5, forum participants discussed broader aspects of the ABET criteria. The two general topics that received the most attention were the presentation of definitions of key terms in the new criteria and the overall requirements for an engineering degree.

Definitions

One proposed straightforward change to the criteria that many participants praised was the presentation of the definitions of key terms (*program educational objectives*, *student outcomes*, *assessment*, and *evaluation*) in one place—in a section immediately following the background section and before the descriptions of the general criteria and program criteria—rather than throughout the document. Patricia Daniels (University of Washington) cited this as an improvement in the revised document, and her praise was echoed by Phillip Borrowman (Hanson Professional Services), who noted that providing the definitions up front adds an explicitness to the criteria that is valuable to programs and program evaluators.

However, Borrowman added, there is some confusion caused by the fact that the document has definitions in two places—definitions of basic terms in Section 1 and definitions related to student outcomes in what appears to be a "preamble" to Criterion 3. The existence of two separate groups of definitions might cause readers to wonder whether there is a greater importance of one location over the other, and he suggested combining all the definitions in Section 1.

He also identified some ambiguity in some of the criteria, which might create difficulties both for people running engineering programs and for those evaluating them. Borrowman highlighted the use of the term "multidisciplinary" as an example, suggesting that "the word multidisciplinary should be added to criterion 3.7, ahead of the word 'teams,'" so that the revised criterion would read: "An ability to function effectively on multidisciplinary teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty." In his experience, Borrowman noted, single disciplinary teams rarely exist in industry. Again, he suggested, some of the ambiguity related to this word could be eliminated by expanding and clarifying the definitions of terms in Section 1.

Engineering Degree Requirements

Discussion of the overall requirements for an engineering degree focused on how many hours or years it should take to earn a degree.

David Whitman (University of Wyoming), past president of the National Council of Examiners for Engineering and Surveying, raised the question of whether ABET should define a minimum number of semester credit hours for an accredited bachelor's degree in engineering. Currently one academic year is defined as the lesser of 32 semester credits or one-fourth of the total credits required for graduation, and both the existing and proposed Criterion 5 specify a minimum of 1 academic year of a combination of college-level mathematics and basic sciences and 1½ academic years of engineering topics. He suggested that it might make sense to request that ABET's Engineering Accreditation Commission reexamine the concept of requiring a specific minimum, by setting either an absolute minimum requirement of total credit hours for degree completion or an absolute minimum number of credit hours for engineering-related courses. Having this specific requirement set out by ABET, which is highly respected by employers, administrators, and legislators, might help stop the trend toward a decreasing number of credit hours, particularly a decreasing number of engineering-related credit hours.

Donna Riley (Virginia Tech) noted that regardless of the length of time required to complete an engineering degree, it will always be necessary to decide on priorities in the curriculum.

Chapter 3
Preparing Students for a Career in Engineering

Forum attendees considered whether the proposed ABET criteria would help ensure that students from accredited institutions are prepared for a career in engineering. A panel discussion was held to address how well an engineering education at ABET-accredited institutions prepares graduates for industry needs, how well the proposed criteria might prepare students to become lifelong learners, and whether licensing of engineers should be included in the criteria.

The ABET Criteria and Industry Needs

Several attendees said that the new criteria do a good job of identifying the sorts of engineering skills that contemporary companies are looking for in their new hires.

Atsushi Akera (Rensselaer Polytechnic Institute) praised the reorganization of the student outcomes in Criterion 3, and said that, in his view, the new organization makes sense according to how engineering students should be educated. As someone who studies the history of engineering education, he has observed a number of changes in engineering education criteria since the Mann Report,[1] and one of the things he found most notable about the proposed ABET criteria is their focus on professional engineering judgment in the context of practice. This is a welcome shift, he said.

In a brief response to Akera's observation that the revised student outcomes follow the traditional engineering approach, Sheri Sheppard (Stanford University) commented that perhaps there should be an additional student outcome, at the very front of the list, reflecting the step in the engineering process that comes before identifying the problem. That step involves using ethnography and other social sciences to understand the important problems and needs of a particular population.

Dianne Chong (recently retired from Boeing Engineering, Operations, and Technology), who serves on ABET's Engineering Accreditation Commission, said that the revised ABET criteria agree very well with what she has heard from various corporate department heads about what they need from every engineer they hire. Engineers should have good math, science, and engineering skills, be able to work well on teams, and be able to communicate well in both writing and speaking. She noted that companies like Boeing are looking for engineers who can take a systems approach in their work and think outside of their own disciplines. Generally speaking, Chong said, the revised criteria meet the needs of the profession, and serve the same purpose as the current criteria.

Frank Flores (Northrop Grumman Aerospace) was another of the participants who said he found a great deal to like about the new criteria. In particular, he said it appeared that ABET had worked to address many of the concerns related to communication and teamwork in the criteria. His company prefers to hire graduating students who have

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[1] *A Study of Engineering Education* by Charles Riborg Mann, published in 1918 by the Carnegie Foundation for the Advancement of Teaching.

taken part in challenging student projects, and sponsors a number of such projects as a way to identify students who perform well on teams, so the focus on teams in the revised criteria is a positive step.

Ensuring Strong Technical Training

Other participants expressed concerns that the math and science components of the criteria had been somewhat weakened. David Whitman (University of Wyoming) pointed out that the new criteria focus on the application of science and math skills to solve engineering problems rather than on proficiency. While acknowledging that few practicing engineers ever evaluate an integral or solve a differential equation in their everyday work, he nonetheless would have preferred that the criteria keep a student outcome focused specifically on the assessment of math and science proficiency.

Col. Barry Shoop (West Point), who has served on the ABET board, focused on the sentence in the criteria describing in general what engineering students should be able to do:

> These [proposed] criteria are intended to provide a framework of education that prepares graduates to enter the professional practice of engineering who are (i) able to participate in diverse multicultural workplaces; (ii) knowledgeable in topics relevant to their discipline, such as usability, constructability, manufacturability, and sustainability; and (iii) cognizant of the global dimensions, risks, uncertainties, and other implications of their engineering solutions.

There is little in that description that is specific to the discipline of engineering, he commented; indeed, he said he had colleagues who made the argument that a business major could meet those qualifications without having any engineering or technical expertise.

Industry Needs Beyond the Criteria

Some participants contended that the current ABET criteria do not guarantee that a graduating engineering student is ready for a job in industry and that the proposed criteria will do nothing to change that. Others felt that industry advisory boards could help university engineering departments do a more effective job of preparing their students for jobs in industry.

Phillip Borrowman (Hanson Professional Services) observed that companies generally have their own required outcomes for new engineering employees in addition to those specified in the ABET criteria—a clear sign, he said, that ABET's minimum criteria are not sufficient to prepare engineering graduates to enter professional practice. Borrowman noted that when interviewing future graduates in engineering programs, most companies, his own included, are concerned with a program's strength of compliance with its own unique criteria. According to Borrowman, these criteria are "usually more rigorous [than the ABET Criteria], with specifics regarding the open positions we are trying to fill." Borrowman pointed out that in his experience, programs do not list learning experiences in their student outcomes beyond those identified by ABET, as they do not want to expand the criteria to be evaluated further than the (a) through (k) that will be evaluated by EAC. According to Borrowman, "they do not want to do the work necessary to show EAC that they also meet an (l), (m), or (n) outcome."

A number of other forum participants from industry echoed Borrowman's point about companies looking beyond the ABET criteria. Flores said that, while Northrop Grumman always looks at the particular qualifications of individual students, it prioritizes its hiring based on what it has learned are the strengths of different schools and hires from a relatively small set of schools whose strengths match what the company is looking for. Chong said that Boeing's approach is similar, and Wayne Bergstrom (Bechtel Infrastructure and Power Corporation), the 2015–2016 president-elect of ABET, agreed. Although Bechtel is an entirely different business with an entirely different business model, he said, its recruiting of engineering graduates is managed in a way that is very similar to what Flores and Chong described.

Borrowman summed up the discussion by saying that most companies, when they are interviewing future graduates of an engineering program, are concerned about how well that program complies with the company's specific criteria for engineers. In other words, companies review programs in light of their specific needs and focus their recruitment efforts on programs that best meet those needs. In essence, he said, companies do their own form of "accreditation" and do not recruit from programs whose graduates do not meet the company's criteria.

Borrowman also noted that there is a perverse incentive for engineering schools not to document in their student outcomes anything they do beyond the bare minimum that ABET requires for accreditation. The reason, he explained, is that if a school specifies more ambitious outcomes, it will then be judged on how well it meets those outcomes by program evaluators. The schools do not want to have to do the additional work required to document that they are indeed meeting goals over and above the minimum required by ABET.

Lifelong Learning versus Information Literacy

Riley argued that lifelong learning was omitted from the new criteria and in its place is a call for information literacy, but that the two are not equivalent. Lifelong learning, unlike information literacy, carries with it the expectation that engineers should be able to think critically, act reflectively, and build intellectual power across disciplines. Information literacy is necessary for engineers who wish to engage in lifelong learning, but the latter represents a larger set of skills.

Julie Arendt (Virginia Commonwealth University) said that the revised sixth student outcome—"an ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately"—is much more closely aligned with information literacy. A library can have an excellent collection, she explained, but if students do not use its resources they are not prepared for any sort of lifelong learning.

Licensing

Two presenters addressed the licensing of engineers and its relationship with the ABET criteria.

Stuart Walesh, an independent consultant, began by noting that the proposed criteria are similar to the existing criteria in that they make no mention of licensure. This is a serious omission, he said, and he made a case for including licensing in the criteria, arguing that licensed practicing engineers are generally more likely to be competent, up to date on engineering practices, and ethical than their nonlicensed counterparts. They are more likely to be current, he explained, because of the continuing education requirements that come with licensure, and more likely to be ethical in part because they know they will be held accountable by licensing boards. This general superiority of licensed engineers is one of the reasons that engineering students should be exposed to the basics of licensure.

In addition, having a license gives engineers an advantage in the search for jobs, even if they are self-employed or starting their own company. For all these reasons, Walesh said, it makes sense to familiarize engineering students with licensing and the advantages of being licensed. He suggested that it would be enough to revise the second sentence in the proposed Criterion 5(c) to read as follows:

> Students must be prepared to enter the professional practice of engineering through 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 constraints *and recognizing the role of the licensed engineer in protecting public health, safety, and welfare* [proposed addition in italics].

Whitman viewed the licensing of engineers from a different perspective. State licensing boards—guided by the National Council of Examiners for Engineering and Surveying (NCEES) Model Law requirements and by the laws of the individual state—determine whether a candidate has the competency to safeguard the health, safety, and welfare of the public during his or her practice. An ABET-accredited bachelor's degree in engineering is a universal requirement for licensure exams in the United States.

He agreed that ethics are a crucial aspect of engineering licensing, noting that nearly 40 percent of all disciplinary actions carried out by the registration boards concern ethics, and not engineering competence. Entry-level engineers therefore need to have been given a strong base in ethical behavior as part of their BS degree.

He affirmed the importance of lifelong learning, because most jurisdictions require engineers to engage in continuing professional education for license renewal. And being able to communicate and function on teams is another critical skill particularly for entry-level engineers, as nearly all their assignments will involve working with a number of different people.

Chapter 4
Specific Changes in Criteria Wording or Emphasis

Successful engineering schools do more than simply provide students with the technical tools they will need in their careers. The best engineers are well rounded, with an understanding of the broader societal context in which their engineering solutions will operate and an ability to work with all sorts of people, including those from different disciplines and cultural backgrounds. How well the proposed criteria address these sorts of nontechnical issues was a major theme of the forum discussions.

Several participants suggested that the new criteria may lead to a weakening of what engineers are expected to be able to do. As Donna Riley (Virginia Tech) put it, the proposed changes could lower expectations for engineering professionals, leading to a deprofessionalization of engineers, a loss in stature for the profession, and possibly a reduction of the scope of engineers' responsibilities in the workplace and in society.

Forum participants specifically considered the change in the criteria from "general education" to "broad education," omission of the term "multidisciplinary," and how well the proposed criteria would encourage diversity in engineering schools.

"General Education" versus "Broad Education"

Several speakers expressed concern about part (c) in the proposed Criterion 5, which specifies that an engineering curriculum must have "a broad education component that includes humanities and social sciences, complements the technical content of the curriculum, and is consistent with the program educational objectives." In particular, comments focused on the change in wording from "general education" in the current ABET criteria to "broad education" in the proposed criteria, and on the specification of humanities and social sciences as broad subject areas in which engineering students should take courses.

Patricia Daniels (University of Washington) noted that there have been reports of some engineering programs reducing their general education requirements in the face of requests from state legislatures to reduce the number of overall credits in engineering degrees. Changing the criteria to specify courses in the humanities and social sciences might lead some engineering programs to add courses instead.

According to Col. Barry Shoop (West Point), the proposed change from a general education component to a broad educational component that includes humanities and social sciences has caused some in the engineering education community to worry about unintended consequences for engineering programs. One area of concern is variability in how institutions define humanities and social sciences. For instance, universities with a college of humanities and/or social sciences might restrict the definition of courses in these areas to those taught by the college. Such a restriction would not necessarily reflect the sorts of courses that engineering majors should take to get the broad education that will help them understand the world in which they will be designing.

Riley provided a historical overview of what engineering students have been expected to study beyond math, the physical sciences, and engineering. For nearly a century reports called for the broad education of engineers, and before the current ABET standards were in place engineering students were expected to have one year's worth of courses in the humanities and social sciences. EC2000 did away with the time requirements for courses in these areas and replaced them with outcomes that drew instead on content from the humanities and social sciences, while explicitly requiring the "broad education" necessary to understand the social context of engineering.

EC2000 also specified in Criterion 5 that adequate attention and time must be given to "general education." The proposed changes remove the language concerning a "broad education" from Criterion 3 and the phrase "adequate attention and time" from Criterion 5, with the result that "broad education" is characterized in the new criteria as simply a component of a technical education.

The result of these changes, Riley said, would be to remove the requirements that help engineers understand the social context in which they are designing. Engineering, she argued, should be defined in such a way that engineers understand their role in solving extreme poverty, for example, but they cannot be effective in that role if they do not have an understanding of issues such as social inequality. The stakes are high and, as written, the new criteria leave out the social context that engineers must understand in order to work on societal problems.

Jon Kuhl (University of Iowa), a member of the Web audience, asked about the rationale for the more restrictive definition of the general education component of Criterion 5, specifically the requirement that this component include work in the humanities and social sciences. His institution, he said, uses designations such as communication and culture, society, and the arts.

Diane Rover (Iowa State University), a member of the executive committee of ABET's Engineering Accreditation Commission, responded that the Criteria Committee appreciates feedback on the proposed changes. Regarding the change from "general education" to "broad education," she said, "That is…definitely going to be refined, and likely [without]…quite such specific words. There was no intent to overspecify that."

Omission of the Word "Multidisciplinary"

One omission from the new criteria that attracted attention from several participants was the word "multidisciplinary." Simon Pitts (Northeastern University), a member of the Web audience, observed that a key disconnect between students' experiences at universities and what they encounter in the engineering workplace is that the vast majority of engineering practice today is done in multidisciplinary teams, whereas engineering students get relatively little experience working in such teams. Omission of the word "multidisciplinary" in the new criteria might be a retrograde step in terms of preparing students for their careers.

Riley also questioned the omission of "multidisciplinary" from the proposed criteria: It sends the signal that ABET no longer values an engineer's ability to work with people of different backgrounds, which could eventually result in engineers who are ill equipped to work on complex systems, such as electric power or transportation.

SPECIFIC CHANGES IN CRITERIA WORDING OR EMPHASIS

Frank Flores (Northrop Grumman Aerospace) agreed that introduction to multidisciplinary teams is critical to engineering education—and in terms of expertise not just in different engineering disciplines but also in nonengineering fields.

Karan Watson (Texas A&M University), a past president of ABET, offered an explanation for the decision to remove “multidisciplinary” from the proposed new criteria. “One of the problems with ‘multidisciplinary’ is you want people to have a discipline before you bring them on,” she said, but many engineering undergraduates do not develop much strength in a discipline until the later stages of their education. Many engineering programs have therefore ended up defining “multidisciplinary” for the purpose of their ABET evaluations in ways that are not truly multidisciplinary in the way that most working engineers think of the word. For example, a school might define a multidisciplinary team as having one person working on radiofrequency signals, another working on the controls, a third working on the communications, and so on. There is great variation in how different schools define the term “multidisciplinary.”

It would be a positive step to get people talking about what “multidisciplinary” should mean in terms of satisfying the ABET criteria, Watson said, “but I think that would be a significant change for many schools if you defined it as meaning having to work with people who are getting different degrees, even outside of engineering, because that is not necessarily a common definition of multidisciplinary teams right now in the criteria.”

Rover agreed with Watson’s explanation. Many schools have operational definitions of “multidisciplinary” that do not require students to work with students from different majors. Program evaluators have traditionally found such definitions to be acceptable, which is one of the reasons that “multidisciplinary” does not appear in the proposed criteria.

Diversity

A portion of the forum discussion concerned diversity in the engineering profession and how to encourage it. As Riley noted, although diversity is mentioned in the new ABET document, which says that students should be “able to participate in diverse multicultural workplaces,” there are no student outcomes in Criterion 3 that directly address diversity.

Darryll Pines (University of Maryland, College Park) reported that studies have shown that diversity—not just racial and ethnic diversity, but all types—enhances product development and helps lives in general, and truly diverse teams lead to greater innovation. And he noted that the American Society of Civil Engineers has a 5-year strategic plan for increasing diversity in the engineering profession. He stressed the importance of including diversity in the student outcomes of Criterion 3.

Several forum participants echoed Pines’ comments that diversity should be understood as more than racial, ethnic, and gender diversity.

Watson pointed out that diversity can mean different things in different situations. Diversity in the United States is not necessarily the same as diversity in another country, she said, offering as an example the Texas A&M University campus in Qatar, where 42 percent of the engineering students are women: gender diversity is not as pressing an issue there as it is on many US campuses. Since ABET has a global presence, with accredited engineering programs around the world, Watson said, any diversity criteria must take into account the fact that diversity needs may vary significantly from place to place.

Flores added that increasing diversity will require the development of more inclusive environments that are welcoming to and supportive of all engineers regardless of their race, ethnicity, cultural background, gender, sexual orientation, sexual identity, or beliefs.

Diane Matt (WEPAN) seconded this point. A number of engineering groups have emphasized the importance of fostering inclusiveness, yet there is nothing in the proposed ABET criteria about such inclusiveness. “I do not see anything in Criteria 3 and 5 that addresses recruitment, nurturing, and welcoming for underrepresented groups,” she said. She hears from people on various campuses that engineering college cultures are rarely inclusive, and indeed that they are often quite unwelcoming to anyone who is not a straight white male. “It is time to change that.”

In particular, Matt continued, diversity and inclusion are crucial to the success of companies in today’s global marketplace. She cited a 2011 *Forbes* article on the results of interviews with 300 senior-level executives from top companies around the world: they reported that a diverse, inclusive workforce is a critical element in attracting and retaining top talent. She added that, while companies located in some homogeneous places may find it difficult to assemble a truly diverse workforce, it is always possible to create inclusiveness.

Are We Asking Too Much of ABET?

Norman Fortenberry (ASEE) articulated a consistent theme throughout the discussion of the specific wording of the proposed revisions, noting two different approaches to understanding the value of the revisions. One questioned what the minimum requirements for an engineer are or ought to be, and then tried to determine whether the revisions achieve that minimum. The other approach questioned whether accreditation should be about the minimum or baseline, or whether it is aspirational. Trying to bridge these two different approaches might be a difficult but critical challenge.

Watson supported the notion that determining baseline expectations for accredited programs should be a primary consideration for ABET. In response to the concern that ABET criteria fall short because they do not address specific issues sufficiently, she expressed concern that ABET’s role was misunderstood: the organization sets criteria for accreditation, not for total excellence. It is a strength of the ABET approach that schools are allowed to specify their own vision of excellence for their engineering programs.

Riley countered that there is no point in “setting the bar low” and that the purpose of the NAE forum was to identify areas and details that are missing from the proposed criteria. Things that are important for beginning engineers to know can be specified in the ABET criteria without placing too heavy a load on universities, she argued.

Chapter 5
Next Steps

At the conclusion of the forum, Joe Sussman, ABET's chief accreditation and information officer, reiterated that work on Criteria 3 and 5 is still in progress, recognized the importance of the forum for generating comments on the proposed changes, and encouraged interested stakeholders to continue to offer their opinions and suggestions about the proposed criteria to ABET. He strongly suspected that there would be further revisions and another cycle of feedback before the final approval of the revisions, but acknowledged that the Area Delegation might decide that enough work had been done, the changes to the criteria were acceptable, and approve them.

Patricia Daniels (University of Washington) offered her own take on the likely next steps. "I cannot tell you what the Criteria Committee will vote or what the Engineering Accreditation Commission will vote," she said, "but I have seen some needs for some change, one of which is I am more than willing in Criterion 5(c) to remove the words 'humanities and social sciences.' I have learned now that was the wrong terminology." She said she would recommend to the members of the Criteria Committee that they revise the criteria and send them back out for more comments but, again, could not guarantee how the EAC or Area Delegation would proceed.

If the Criteria Committee approved the criteria as written, Sussman said, the ABET board would vote on the proposed changes in October 2016, at which point they would be either approved or sent out for another round of review and comment. If the revised criteria were approved in October, they would not be effective until the 2017–2018 accreditation cycle at the earliest. But because of the breadth and complexity of the proposed changes, the Engineering Area Delegation might recommend to the EAC that there be a phase-in period for the changes.

Finally, Atsushi Akera (Rensselaer Polytechnic) described other opportunities for providing feedback on the proposed criteria. The American Society for Engineering Education was planning to hold a virtual conference in late February or early March of 2016 to provide feedback on the proposed changes. And in late June 2016, a Town Hall session at the ASEE annual meeting in New Orleans will be dedicated to the proposed changes in the ABET criteria.

Appendix A

Forum Agenda

FORUM ON PROPOSED REVISIONS TO ABET ENGINEERING ACCREDITATION COMMISSION GENERAL CRITERIA ON STUDENT OUTCOMES AND CURRICULUM (CRITERIA 3 AND 5)

Keck Center, Room 100
500 Fifth Street, NW, Washington, DC 20001

Tuesday, February 16, 2016

11:00 am	**Welcome and Introductions** • **Alan Cramb,** President, Illinois Institute of Technology; NAE Forum Planning Committee Chair *(via Web-Ex)*
11:10 am	**Summary of ABET-EAC Proposed Revisions to General Criteria 3 and 5 and the Revision Process** • **Joe Sussman**, Chief Accreditation and Information Officer, ABET • **Patricia D. Brackin,** Professor of Mechanical Engineering, Rose-Hulman Institute of Technology; Chair of the EAC Criteria Committee *(via Web-Ex)*
11:50 am	**Panel 1: Perspectives from Academia** **Moderator:** • **Karan Watson**, Provost and Executive Vice President, Texas A&M University; NAE Forum Planning Committee Member **Panelists:** • **Gerald D. Holder,** U.S. Steel Dean of Engineering and Professor of Chemical Engineering, Swanson School of Engineering, University of Pittsburgh *(via Web-Ex)* • **Diane T. Rover,** University Professor, Department of Electrical and Computer Engineering, Iowa State University *(via Web-Ex)* • **Mickey Wilhelm**, Professor, Industrial Engineering; Dean Emeritus, JB Speed School of Engineering, University of Louisville *(via Web-Ex)* • **Sheri Sheppard,** Associate Vice Provost of Graduate Education and Associate Chair for Undergraduate Curriculum, Mechanical Engineering, Stanford
12:45 pm	**Open Discussion**
1:10 pm	**Break to Retrieve Box Lunch**

1:20 pm	**Panel 2: Perspectives from the Profession** **Moderator:** • **Wayne Bergstrom***,* Principal Engineer, Bechtel Infrastructure and Power Corporation; 2015-2016 President-Elect, ABET; NAE Forum Planning Committee Member **Panelists:** • **Dianne Chong**, VP of Assembly, Factory and Support Technologies, The Boeing Company (ret.) • **Frank Flores**, VP Engineering, Northrop Grumman • **C. Diane Matt***,* Executive Director, Women in Engineering ProActive Network (WEPAN) • **Stuart G. Walesh**, **P.E.,** Independent Consultant • **David L. Whitman**, H.T. Person Professorship of Engineering Education, Department of Electrical & Computing Engineering, University of Wyoming
2:20 pm	**Open Discussion**
2:45 pm	**Break**
3:00 pm	**Panel 3: Summarizing the Pros and Cons of the Proposed Criteria Changes** **Moderator:** • **Mary Boyce,** Dean of Engineering and Morris A. and Alma Schapiro Professor, The Fu Foundation School of Engineering and Applied Science, Columbia University; NAE Forum Planning Committee Member **Panelists:** • **Phillip Borrowman, P.E.,** Senior Vice President, Hanson Professional Services, Inc. (ret.); Past-President, ABET *(via Web-Ex)* • **Donna Riley,** Professor, Department of Engineering Education, Virginia Tech • **Patricia D. Daniels,** Affiliate Professor of Electrical Engineering, University of Washington, Emeritus Professor, Seattle University • **COL Barry L. Shoop,** Professor and Head, Department of Electrical Engineering and Computer Science, West Point *(via Web-Ex)*
3:55 pm	**Open Discussion**
4:15 pm	**General Discussion** **Moderator:** • **Norman Fortenberry,** Executive Director, American Society for Engineering Education; NAE Forum Planning Committee Member
4:40 pm	**Recap and Next Steps** • **Alan Cramb,** President, Illinois Institute of Technology *(via Web-Ex)*
5:00 pm	**Adjourn**

Appendix B

Criteria for Accrediting Engineering Programs

Effective for Reviews during the 2016–2017 Accreditation Cycle

Definitions

While ABET recognizes and supports the prerogative of institutions to adopt and use the terminology of their choice, it is necessary for ABET volunteers and staff to have a consistent understanding of terminology. With that purpose in mind, the Commissions will use the following basic definitions:

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

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

<u>Assessment</u> **-** 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.

<u>Evaluation</u> **-** 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.

This document contains three sections:

The first section includes important **definitions** used by all ABET commissions.

The second section contains the **General Criteria for Baccalaureate Level Programs** that must be satisfied by all programs accredited by the Engineering Accreditation Commission of ABET and the **General Criteria for Masters Level Programs** that must be satisfied by those programs seeking advanced level accreditation.

The third section contains the **Program Criteria** that must be satisfied by certain programs. The applicable Program Criteria are determined by the technical specialties indicated by the title of the program. Overlapping requirements need to be satisfied only once.

These criteria are intended to assure quality and to foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of constituencies in a dynamic and competitive environment. It is the responsibility of the institution seeking accreditation of an engineering program to demonstrate clearly that the program meets the following criteria.

I. General Criteria For Baccalaureate Level Programs

All programs seeking accreditation from the Engineering Accreditation Commission of ABET must demonstrate that they satisfy all of the following General Criteria for Baccalaureate Level Programs.

Criterion 1. Students

Student performance must be evaluated. Student progress must be monitored to foster success in attaining student outcomes, thereby enabling graduates to attain program educational objectives. Students must be advised regarding curriculum and career matters.

The program must have and enforce policies for accepting both new and transfer students, awarding appropriate academic credit for courses taken at other institutions, and awarding appropriate academic credit for work in lieu of courses taken at the institution. The program must have and enforce procedures to ensure and document that students who graduate meet all graduation requirements.

General Criterion 2. Program Educational Objectives

The program must have published program educational objectives that are consistent with the mission of the institution, the needs of the program's various constituencies, and these criteria. There must be a documented, systematically utilized, and effective process, involving program constituencies, for the periodic review of these program educational objectives that ensures they remain consistent with the institutional mission, the program's constituents' needs, and these criteria.

General Criterion 3. Student Outcomes

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.

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) an ability to function on multidisciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

General Criterion 4. Continuous Improvement

The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Other available information may also be used to assist in the continuous improvement of the program.

General Criterion 5. Curriculum

The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The faculty must ensure that the program curriculum devotes adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. The professional component must include:

(a) one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline. Basic sciences are defined as biological, chemical, and physical sciences.

(b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study. 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.

(c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

Students must be prepared for engineering practice through 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.

One year is the lesser of 32 semester hours (or equivalent) or one-fourth of the total credits required for graduation.

General Criterion 6. Faculty

The program must demonstrate that the faculty members are of sufficient number and they have the competencies to cover all of the curricular areas of the program. There must be sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners, as well as employers of students.

The program faculty must have appropriate qualifications and must have and demonstrate sufficient authority to ensure the proper guidance of the program and to develop and implement processes for the evaluation, assessment, and continuing improvement of the program. The overall competence of the faculty may be judged by such factors as education, diversity of backgrounds, engineering experience, teaching effectiveness and experience, ability to communicate, enthusiasm for developing more effective programs, level of scholarship, participation in professional societies, and licensure as Professional Engineers.

General Criterion 7. Facilities

Classrooms, offices, laboratories, and associated equipment must be adequate to support attainment of the student outcomes and to provide an atmosphere conducive to learning. Modern tools, equipment, computing resources, and laboratories appropriate to the program must be available, accessible, and systematically maintained and upgraded to enable students to attain the student outcomes and to support program needs. Students must be provided appropriate guidance regarding the use of the tools, equipment, computing resources, and laboratories available to the program.

The library services and the computing and information infrastructure must be adequate to support the scholarly and professional activities of the students and faculty.

General Criterion 8. Institutional Support

Institutional support and leadership must be adequate to ensure the quality and continuity of the program.

Resources including institutional services, financial support, and staff (both administrative and technical) provided to the program must be adequate to meet program needs. The resources available to the program must be sufficient to attract, retain, and provide for the continued professional development of a qualified faculty. The resources available to the program must be sufficient to acquire, maintain, and operate infrastructures, facilities, and equipment appropriate for the program, and to provide an environment in which student outcomes can be attained.

Ii. General Criteria For Master's Level And Integrated Baccalaureate-Master's Level Engineering Programs

Programs seeking accreditation at the master's level from the Engineering Accreditation Commission of ABET must demonstrate that they satisfy the following criteria, including all of the aspects relevant to integrated baccalaureate-master's programs or stand-alone master's programs, as appropriate.

Criteria Applicable to Integrated Baccalaureate-Master's Level Engineering Programs

Engineering programs that offer integrated baccalaureate-master's programs must meet all of the General Criteria for Baccalaureate Level Programs and the Program Criteria applicable to the program name, regardless of whether students in these programs receive both baccalaureate and master's degrees or only master's degrees during their programs of study. In addition, these programs must meet all of the following criteria. If any students are admitted into the master's portion of the combined program without having completed the integrated baccalaureate portion, they must meet the criteria given below.

Criteria Applicable to all Engineering Programs Awarding Degrees at the Master's Level

Students and Curriculum

The master's program must have and enforce procedures for verifying that each student has completed a set of post-secondary educational and professional experiences that:

a) Supports the attainment of student outcomes of Criterion 3 of the general criteria for baccalaureate level engineering programs, and

b) Includes at least one year of math and basic science (basic science includes the biological, chemical, and physical sciences), as well as at least one-and-one-half years of engineering topics and a major design experience that meets the requirements of Criterion 5 of the general criteria for baccalaureate level engineering programs.

If the student has graduated from an EAC of ABET accredited baccalaureate program, the presumption is that items (a) and (b) above have been satisfied.

The master's level engineering program must have and enforce policies and procedures ensuring that a program of study with specific educational goals is developed for each student. Student performance and progress toward completion of their programs of study must be monitored and evaluated. The program must have and enforce procedures to ensure and document that students who graduate meet all graduation requirements.

The master's level engineering program must require each student to demonstrate a mastery of a specific field of study or area of professional practice consistent with the master's program name and at a level beyond the minimum requirements of baccalaureate level programs.

The master's level engineering program of study must require the completion of at least 30 semester hours (or equivalent) beyond the baccalaureate program.

Each student's overall program of post-secondary study must satisfy the curricular components of the baccalaureate level program criteria relevant to the master's level program name.

Program Quality

The master's level engineering program must have a documented and operational process for assessing, maintaining and enhancing the quality of the program.

Faculty

The master's level engineering program must demonstrate that the faculty members are of sufficient number and that they have the competencies to cover all of the curricular areas of the program. Faculty teaching graduate level courses must have appropriate educational qualifications by education or experience. The program must have sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners, as well as employers of students.

The master's level engineering program faculty must have appropriate qualifications and must have and demonstrate sufficient authority to ensure the proper guidance of the program. The overall competence of the faculty may be judged by such factors as education, diversity of backgrounds, engineering experience, teaching effectiveness and experience, ability to communicate, level of scholarship, participation in professional societies, and licensure.

Facilities

Means of communication with students, and student access to laboratory and other facilities, must be adequate to support student success in the program, and to provide an atmosphere conducive to learning. These resources and facilities must be representative of current professional practice in the discipline. Students must have access to appropriate training regarding the use of the resources available to them.

The library and information services, computing and laboratory infrastructure, and equipment and supplies must be available and adequate to support the education of the students and the scholarly and professional activities of the faculty.

Remote or virtual access to laboratories and other resources may be employed in place of physical access when such access enables accomplishment of the program's educational activities.

Institutional Support

Institutional support and leadership must be adequate to ensure the quality and continuity of the program. Resources including institutional services, financial support, and staff (both administrative and technical) provided to the program must be adequate to meet program needs. The resources available to the program must be sufficient to attract, retain, and provide for the continued professional development of a qualified faculty. The resources available to the program must be sufficient to acquire, maintain, and operate infrastructure, facilities, and equipment appropriate for the program, and to provide an environment in which student learning outcomes.

Appendix C

2016–2017 Criteria for Accrediting Engineering Programs Proposed Changes

Definitions

While ABET recognizes and supports the prerogative of institutions to adopt and use the terminology of their choice, it is necessary for ABET volunteers and staff to have a consistent understanding of terminology. With that purpose in mind, the Commissions will use the following basic definitions:

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.

This document contains three sections:

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The third section contains the **Program Criteria** that must be satisfied by certain programs. The applicable Program Criteria are determined by the technical specialties indicated by the title of the program. Overlapping requirements need to be satisfied only once.

~~These criteria are intended to assure quality and to foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of constituencies in a dynamic and competitive environment. It is the responsibility of the institution seeking accreditation of an engineering program to demonstrate clearly that the program meets the following criteria.~~

These criteria are intended to provide a framework of education that prepares graduates to enter the professional practice of engineering who are (i) able to participate in diverse multicultural workplaces; (ii) knowledgeable in topics relevant to their discipline, such as usability, constructability, manufacturability and sustainability; and (iii) cognizant of the global dimensions, risks, uncertainties, and other implications of their engineering solutions. Further, these criteria are intended to assure quality to foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of constituencies in a dynamic and competitive environment. It is the responsibility of the institution seeking accreditation of an engineering program to demonstrate clearly that the program meets the following criteria.

The Engineering Accreditation Commission of ABET recognizes that its constituents may consider certain terms to have certain meanings; however, it is necessary for the Engineering Accreditation Commission to have consistent terminology. Thus, the Engineering Accreditation Commission will use the following definitions:

Basic Science – Basic sciences consist of chemistry and physics, and other biological, chemical, and physical sciences, including astronomy, biology, climatology, ecology, geology, meteorology, and oceanography.

College-level Mathematics – College-level mathematics consists of mathematics above pre-calculus level.

Engineering Science – Engineering sciences are based on mathematics and basic sciences but carry knowledge further toward creative application needed to solve engineering problems.

Engineering Design – Engineering design is the process of devising a system, component, or process to meet desired needs, specifications, codes, and standards within constraints such as health and safety, cost, ethics, policy, sustainability, constructability, and manufacturability. It is an iterative, creative, decision-making process in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally into solutions.

Teams – A team consists of more than one person working toward a common goal and may include individuals of diverse backgrounds, skills, and perspectives. One Academic Year – One academic year is the lesser of 32 semester credits (or equivalent) or one-fourth of the total credits required for graduation with a baccalaureate degree.

Criterion 3. Student Outcomes

~~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.~~

~~(a) an ability to apply knowledge of mathematics, science, and engineering~~

~~(b) an ability to design and conduct experiments, as well as to analyze and interpret data~~

~~(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability~~

~~(d) an ability to function on multidisciplinary teams~~

~~(e) an ability to identify, formulate, and solve engineering problems~~

~~(f) an understanding of professional and ethical responsibility~~

~~(g) an ability to communicate effectively~~

~~(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context~~

~~(i) a recognition of the need for, and an ability to engage in life-long learning~~

~~(j) a knowledge of contemporary issues~~

~~(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.~~

The program must have documented student outcomes. 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.

1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.

2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.

3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

4. An ability to communicate effectively with a range of audiences.

5. 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.

6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.

7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty.

Criterion 5. Curriculum

~~The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The faculty must ensure that the program curriculum devotes adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. The professional component must include:~~

~~(a) one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline. Basic sciences are defined as biological, chemical, and physical sciences.~~

~~(b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study. The engineering sciences have their roots in mathematics and basic sciences but carry knowledge 28 2016-2017 Criteria for Accrediting Engineering Programs – Proposed Changes 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.~~

~~(c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.~~

~~Students must be prepared for engineering practice through 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.~~

~~One year is the lesser of 32 semester hours (or equivalent) or one-fourth of the total credits required for graduation.~~

The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The curriculum must support attainment of the student outcomes and must include:

(a) one academic year of a combination of college-level mathematics and basic sciences (some with experimental experience) appropriate to the program.

(b) one and one-half academic years of engineering topics, consisting of engineering sciences and engineering design appropriate to the program and utilizing modern engineering tools.

(c) a broad education component that includes humanities and social sciences, complements the technical content of the curriculum, and is consistent with the program educational objectives.

Students must be prepared to enter the professional practice of engineering through 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 constraints.