AIChE Education and Accreditation Committee
Outline of Guidelines for PEVs and Programs
PEV and Program Guidance Subcommittee
31 August 2016

Introduction and Purpose

As provided in the charge of the AIChE Education and Accreditation (E&A) Committee, one function of the Committee is that it "advises schools on methods and standards of chemical engineering education." In addition, our Committee's Manual of Procedures (2005) indicates the Committee should:

- Provide consistent interpretations of ABET Criteria and Policy across the diverse population of chemical engineering programs that seek accreditation ensuring minimum standards are met while avoiding strict, narrow interpretations.
- Help chemical engineering programs prepare for accreditation visits in ways that improve their programs without undue effort.

Based on the experience and feedback from program evaluators, this document summarizes the guidance and recommendations made by the E&A Committee to meet the above objectives and goals. The intention of this document is to summarize the guidance and recommendations that would be appropriate for use as a reference or in structuring training for the benefit of chemical engineering programs and program evaluators alike. It is recognized that ABET Criteria (as documented in the Engineering Accreditation Commission Criteria for Accrediting Engineering Programs) and Policy (as documented in the Accreditation Policy and Procedure Manual or APPM) will change over time, and this document should be updated regularly to provide the best information available. This document will be made available to AIChE PEVs before the fall accreditation visits begin and be made available on the Education & Accreditation Committee page of the AIChE web site.

The objective of "advising programs on methods and standards of chemical engineering education" is not addressed in this document to avoid any position which may promote a strict, narrow interpretation. Consequently, the committee objective is provided through presentations and training programs.

The guidance and recommendations provided by the E&A Committee are not intended to be in conflict with ABET Criteria or Policy and should be interpreted in the context of the evaluation team in a manner consistent with the ABET evaluation process.

Criterion 3. Student Outcomes

Guidance pertaining to Student Outcomes will be revised over time as the requirements of Criterion 3 are expected to change and evolve. Consequently, some of the points addressed below may be irrelevant later.

1. Multidisciplinary teams. Student Outcomes are outcomes for which students are to be prepared to achieve at the time of graduation. The process of preparing students to achieve this outcome may be conducted in an environment where only chemical engineering students work in teams. While working in multidisciplinary teams prior to graduation may enhance the educational experience of students, such an environment is not necessary to meet this outcome.

2. Articulated Outcomes. As required by ABET, "student outcomes are (a) through (k) plus any additional outcomes". Consequently, programs do have the option of specifying additional outcomes to address, for example, their Program Educational Objectives or requirements of the Chemical Engineering Program Criteria. Programs should avoid convolution of ABET outcomes so that the attainment of each ABET outcome by students can be assessed. All articulated outcomes should be clearly stated as outcomes, otherwise attainment of the outcomes may be difficult to assess. All student outcomes identified by the program must be assessed.

Criterion 5. Curriculum

1. Categorizing Coursework: Fulfilling Engineering Topics (ET) or Math and Basic Sciences (MBS) Requirements. The ABET Criteria for Engineering Programs defines both of these terms and should be consulted to ensure definitions are current. At present, the General Criteria specifically define Basic Sciences as biological, chemical, and physical sciences. The General Criteria further state that Engineering Topics consists of courses pertaining to Engineering Sciences and/or Engineering Design.

    a. Engineering Sciences. Engineering Sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. Therefore, to be categorized as fulfilling ET requirements as Engineering Science, a course must demonstrate engineering application of mathematics and basic sciences. To be categorized as an Engineering Science, there is no requirement or restriction on the college or department in which the course is taught or the pedigree or academic home of faculty teaching it. Supporting evidence of engineering application should be evaluated for all courses claiming to have engineering science content. Examples of such engineering application evidence might include course syllabi, textbooks, homework, project reports, examinations, or other course materials, and information from instructor and student interviews. Examples of courses that should not be categorized as Engineering Science include biochemistry, microbiology, and physical chemistry (all of which are clearly defined as Basic Sciences) and courses which could have engineering applications but do not, such as thermodynamics taught in a chemistry department without significant engineering applications or a computer science course without significant engineering applications (both of which could be classified as MBS or “other”). If a basic science course includes significant engineering applications and such content is reflected in the course catalog description, course credit may

be split between ET and MBS categories if justified by the examples of evidence discussed above (e.g., course syllabi, textbooks, etc.).

b. Engineering Design. To be categorized as Engineering Design, the General Criteria specifically state that the course include the process of devising a system, component, or process to meet desired needs such as through a decision-making process in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet stated needs. The operative word is "devising".

   Criterion 5 also specifies that the curriculum culminates in a major design experience based on the knowledge and skills acquired in earlier course work. The criterion is not specific as to how literal the word "culminate" is to be taken and does not specify that the design experience must be the very last element in the curricular schedule, nor does it prohibit any curricular elements following the major design experience. The criterion does not prescribe the specific content of the design experience, the duration of the design experience, or the possible distribution of the design experience over several parallel or sequential courses. Criterion 5 does state that the major culminating design experience must prepare students for engineering practice.

   Criterion 5 also specifies that the major design experience must incorporate appropriate engineering standards and multiple realistic constraints. Criterion 3 (Student Outcomes) suggests that "realistic constraints" may include economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability issues. Criterion 5 does not specifically define "appropriate engineering standards". The chemical engineering profession has not codified standards of practice for its discipline or its processes, although some companies and organizations do develop and maintain standards, for example as related to piping practice, process instrumentation and control, process safety, etc. With regard to process safety, AIChE has adopted the use of “Recognized and Generally Accepted Good Engineering Practice (RAGAGEP)” which are “based on established codes, standards, published technical reports or recommended practices or similar documents”, and this definition has, in turn, been adopted by OSHA. Nevertheless, “appropriate engineering standards” may be widely interpreted in the context of the program’s major chemical engineering design experience.

   For courses that specify that they include Engineering Design content, evidence in support of that objective might include course syllabi, textbooks, homework, project reports, examinations, or other course materials, and information from instructor and student interviews.

2. Curriculum Content. Criterion 5 requires that the curriculum include one year of mathematics and basic sciences (MBS) and one and one-half years of Engineering Topics (ET). Criterion 5 goes on to explain that one year is the lesser of 32 semester hours (or

equivalent) or one-fourth of the total credits required for graduation. If a program fails to meet these requirements, this may result in a program shortcoming during an evaluation visit. Often, it is helpful for a PEV to consider the sample transcripts of recent graduates in the determination of the type of shortcoming that is appropriate. Also, programs may make changes to their curriculum so that the requirements of the Criterion are currently satisfied even though recent graduates may not have met the requirements of Criterion 5. Under these circumstances, a previously accredited program may be in compliance with Criterion 5 even though problems were identified during the transcript evaluation process (but this guidance may not apply to new programs as discussed below).

Chemical Engineering Program Criteria

The current Chemical Engineering Program Criteria includes only requirements for the program curriculum as follows:

> The curriculum must provide a thorough grounding in the basic sciences including chemistry, physics, and/or biology, with some content at an advanced level, as appropriate to the objectives of the program. The curriculum must include the engineering application of these basic sciences to the design, analysis, and control of chemical, physical, and/or biological processes, including the hazards associated with these processes.

To assist in this program decision process, the following points address frequent questions regarding the Chemical Engineering Program Criteria.

1. Basic Sciences. Chemistry and physics are mandated by the Program Curriculum Criterion, but biology is optional. The General Criteria specify that the basic sciences must include an experimental experience. The Program Curriculum Criterion does not define "thorough grounding", "some content", nor "advanced level". In the years prior to EC2000, the Program Curriculum Criterion specified a half year of advanced chemistry beyond college level General Chemistry. Based on that precedent, advanced level might be considered as any courses beyond college level general chemistry, general physics, or general biology. The operative phrase for thorough grounding and the amount and content of advanced basic science is "as appropriate to the objectives of the program", and it is in that context that compliance with the Program Curriculum Criterion must be evaluated. The Program Curriculum Criterion does not specify whether particular chemistry subjects such as organic or physical or instrumental analysis, or particular physics or biology topics, or particular mathematics courses beyond differential equations or linear algebra are mandated, but only those whose mastery would reasonably be required to achieve the objectives of the program. It is incumbent on the program to justify how their mathematics and basic science curriculum is appropriate in this context.

2. Engineering Application. The Program Curriculum Criterion also specifies that the curriculum include the engineering application of the science and mathematics curriculum to the design (devising) of chemical (and physical and optionally biological)

processes, to the analysis of the behavior under realistic constraints of such chemical (and physical and optionally biological) processes, and to the control of such processes, and specifically to the analysis and control of the hazards associated with such processes (process safety). As with other parts of the Program Curriculum Criterion, the criterion does not specify precisely what kinds of chemical, physical, or biological processes are to be devised, nor exactly under which or what realistic constraints they must be evaluated or controlled, nor precisely what kinds of associated process hazards must be considered and controlled. However, consideration of process hazards must be a part of the program's process design experience. It is incumbent on the program to justify their choices in all of these matters within the context of the objectives of the program.

3. Process Hazards. As discussed above, programs must state and justify their choices with regard to addressing process hazards (also referred to as process safety education, which is distinct from lab safety training) in the curriculum. Laboratory safety (and lab safety training) is an important aspect of the education of undergraduate students; providing a safe environment for conducting any laboratory work is required by the ABET APPM (discussed below) and is a necessary first step in the preparation of students to address process hazards. While no course in process safety is required by the Program Curriculum Criterion, courses in the curriculum which cover process safety topics must specifically be identified. Also, specific examples of the coverage of process hazards in the curriculum will be helpful in the evaluation process.

4. Process Control. As discussed above, programs must state and justify their choices with regard to the address of process control in the curriculum. Note that the Program Curriculum Criterion does not require that the curriculum include a separate course in process control.

5. Transcript Analysis. PEVs are required to complete a transcript analysis for sample students who graduated in the past year from the program. One requirement of the transcript analysis is that the PEV determine whether the curriculum requirements of the Program Criteria are met including a list of requirements. Based on the Program Curriculum Criterion, the following categories can be easily identified and should be included as Applicable Program Criteria in the Curriculum Analysis Table in Form E351:
   - Chemistry, physics, and (depending on the program objectives) biology
   - Advanced sciences
   - Design, analysis, and control of processes
   - Process hazards

   Such a determination for the curriculum can be made from course titles and course catalog descriptions. Neither the General Criteria nor the Program Criteria specify that the curriculum include specific course titles. As part of the Self-Study, Programs may find that listing required courses in each of these categories will facilitate the transcript evaluation process.

6. New Programs. As stated in the APPM, a new program with deficiencies will be unaccredited (unless reconsidered as part of the ABET appeal process). New programs receiving shortcomings other than a deficiency can receive accreditation although the

accreditation can still lead to an interim report or visit depending upon the nature of the shortcoming. If a new program is found to have a deficiency, the new program must:

- Address the shortcoming so that it is no longer considered a deficiency,
- Require all current and future students to follow the program changes required to address the deficiency, and
- Have at least one student who graduated with the program changes in place that removed the deficiency

to receive accreditation. For example, if a new program has a shortage of hours that leads to a deficiency in Criterion 5, the program must correct the required hours, and all current and future students must abide by the corrected curriculum. The deficiency may not be removed if any student remains on the "uncorrected" curriculum. In addition, at least one student must have graduated from the corrected curriculum within the past academic year before the program can be accredited. Similarly, if there is a deficiency in Criterion 5 related to the design experience, the design experience must be corrected and all current and future students must abide by the new design experience, and at least one student who completed the new design experience must have graduated before the program can be accredited. Typically, the earliest accreditation date associated with a corrected deficiency of a new program is the date at which the first student graduated under the corrected action, but the EAC has the authority to set the date of initial accreditation as specified in the APPM. All guidance with regard to new programs is made with the intention of being consistent with guidance provided in the APPM.

Accreditation Policy and Procedure Manual

The predominant issue which can arise from requirements in the Accreditation Policy and Procedure Manual (APPM) relates to whether facilities are adequate and safe for the intended purpose. Safety is of paramount importance to the chemical engineering profession, and our program criteria require that the curriculum include "analysis and control of the hazards associated with such processes". In addition, providing a safe laboratory environment for the students is critically important. The PEV should tour program laboratory facilities as part of the site visit. During this time, the PEV may check several items indicating that safe laboratory practices are being followed such as:

- Ensuring that fume hoods, emergency showers, and eye wash stations are properly maintained and fire extinguisher inspections are up to date;
- Ensuring that materials are not stored inappropriately (such as flammable materials in commercial refrigerators, or reactive chemicals stored together); or
- Asking the faculty and technicians that teach/monitor the laboratory courses what safety protocols are in place for classes and what training is required.

If there is a clear program or institution safety violation observed during the visit, it will immediately be brought to the attention of the Program Head or Chair. If feasible, this safety violation should be corrected before the ABET team leaves the university. If the safety violation

is not corrected immediately, the result will be a Program Deficiency for APPM II.G.6.b.(1) (and also potentially Criterion 7. Facilities depending on the circumstances).

A PEV may also observe students during a laboratory class, or see equipment working. Appropriate personal protective equipment (PPE) is required at all times, and procedures must be clear and conducted in a safe manner. If a laboratory safety policy is not being followed by the program or its faculty (e.g., by many students in a lab without appropriate PPE), again, the PEV will immediately bring it to the attention of the Program Head or Chair, and this may result in a program shortcoming for APPM II.G.6.b.(1) (and also Criterion 7. Facilities depending on the circumstances).

It should be noted that the APPM makes clear that neither ABET nor its representatives (including PEVs) certify that the institution's facilities comply with any applicable rules or regulations pertaining to: fire, safety, building, and health codes, or consensus standards and recognized best practices for safety. However, PEVs are required to report any safety issues identified during the evaluation visit, especially related to laboratory facilities.

<u>Relating to the Evaluation Visit</u>

1. Roles of Participants (following ABET guidance with the exception of Liaisons which have a role unique to AIChE):
    a. PEV/Evaluation Team. The PEV works with the visiting team and the team chair in all deliberations about the program under review. The PEV is expected to follow the ABET guidance.
    b. Observers. Observers have the opportunity to learn good practices by experience during the review process with an experienced PEV. One possible task for an observer might be to separately visit some of the supporting departments such as Biology (if biological processes are emphasized by the program). As much as is possible, observers should participate in all aspects of the visit, including review of the self-study, visiting the laboratories, visits with faculty and students. Observers should also work with the PEV in the evaluation of the course materials displayed, particularly the capstone design reports. However, it is important to recognize that input from observers should not interfere with the Evaluation Team process, and that observers are not voting members of the Evaluation Team. Observers should recognize that they are present at the discretion of the Team Chair.
    c. Liaisons. Liaisons are available to provide support to the PEV before and during the accreditation visit on a limited basis. Consequently, liaisons and PEVs should be in contact before the visit. Under ABET's present practices, PEVs may contact liaisons when seeking advice and clarification, particularly on chemical engineering-related issues (e.g., curriculum, design reports, program criteria, etc.). PEVs should not provide the Self-Study to liaisons, but when specific questions arise during the visit, the PEV can share relevant excerpts from the Self-Study to facilitate input from the liaison. It is important to recognize that input from the

liaison should not interfere with the Evaluation Team process, and that all decisions during the Evaluation Visit are team decisions.

2. Prior to the visit
    a. Self-Study preliminary evaluation. PEVs should read the Self-Study so that initial questions can be addressed before the site visit by the program's Point of Contact (POC). PEVs should always include their Team Chair/Co-Chair on correspondence with the POC in addition to others as appropriate (e.g., observer).
    b. Supporting documentation. To the extent possible, PEVs and Program POCs should coordinate what supporting documentation will be provided prior to the visit as well as what documentation will be provided during the visit. Also to the extent possible, coordination of what material can be provided electronically and what material should be provided as hard copy at the time of visit should be discussed between the PEV and POC.
    c. Plan to visit supporting departments. In coordination with the Evaluation Team, PEVs are strongly encouraged to visit supporting departments, particularly chemistry.
3. After the visit
    a. Liaisons/E&A Committee. PEVs should provide completed PEV Worksheet (Form E341) and PEV Report (Form E351) to liaisons so that the liaisons can provide the appropriate background during the annual E&A Committee meeting as part of the process of ensuring consistency across the accreditation process in chemical engineering. In addition to completed forms E341 and E351, other information may be requested from PEVs by the E&A Committee to assist in the task of maintaining consistency between program evaluations and actions.
    b. Communication with the ABET Team. After the visit, the POC should only contact the Team Chair/Co-Chair with regard to matters related to the evaluation visit. The PEV should refer any communication from the POC to the Team Chair/Co-Chair.

Summary

This document summarizes the guidance and recommendations that would be appropriate for use as a reference or in structuring training for the benefit of chemical engineering programs and program evaluators alike. It is recognized that ABET Criteria and Policy will change over time and this document should be updated regularly to provide the best information available. The guidance and recommendations provided by the E&A Committee are not intended to be in conflict with ABET Criteria or Policy and should be interpreted in the context of the evaluation team in a manner consistent with the ABET evaluation process. Any training program developed from the contents of this document should avoid duplication of ABET training. In addition to the material summarized here, training should include example exercises illustrating the issues that can arise as a consequence of the evaluation process for chemical engineering programs.

PEV and Program Guidance Subcommittee

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