AC 2011-1179: A STREAMLINED APPROACH TO DEVELOPING AND ASSESSING PROGRAM EDUCATIONAL OBJECTIVES AND PROGRAM OUTCOMES

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A Streamlined Approach to Developing and Assessing Program Educational Objectives and Program Outcomes
Abstract

Developing and assessing program educational objectives and program outcomes for the purpose of continuous program improvement and to satisfy the criteria for accreditation by ABET can be a daunting task for departments, given the wide range of acceptable options and the evolving expectations of ABET. However, as programs enter their second cycle of accreditation under EC2000, there is greater understanding of, and hopefully better appreciation for, outcomes-based assessment. Presented in this paper are methods of developing and assessing program educational objectives and program outcomes that the authors found to be straightforward, coherent, efficient and effective as they used them within their own departments and provided guidance for faculty in the other engineering and computer science departments at Missouri University of Science and Technology. Case studies are presented as well as lessons learned from recent objectives and outcomes assessment exercises and accreditation visits.

I. Introduction

The radical change in the process employed by ABET to accredit engineering programs with the advent of EC2000 has produced much anguish and confusion for faculty and administrators within departments and institutions attempting to meet new and changing expectations. The terminology and methods used in outcomes-based assessment are often unfamiliar to engineering faculty even though faculty commonly engage in informal continuous improvement efforts in their courses and programs as they endeavor to provide a quality educational experience for their students.

To educate and inform engineering faculty on the evolving expectations of ABET, a plethora of workshops and sessions conducted at engineering society meetings and conferences provide guidance in developing assessment tools and methods. In addition, ABET sponsors webinars and assessment workshops on an ongoing basis. While much useful information about assessment methodology is available through such workshops and sessions as well as in articles that have appeared in various journals, the novice (and expert) can leave such gatherings overwhelmed with options, and flummoxed about what is expected. In addition, sight of the main goal of the process—continuous program improvement—is sometimes lost in the confusion and the perceived effort needed to follow the rules and to meet the expectations of evaluators. Indeed, expectations often vary from evaluator to evaluator even within a single visit team, a phenomenon that ABET is addressing beginning in the 2011-2012 cycle by requiring the completion of online training updates by evaluators prior to conducting accreditation visits.

While there are many valid and effective ways to address the development and assessment of program educational objectives and program outcomes, many faculty are still grasping the fundamentals of the ABET assessment requirements. In fact, only 76% of engineering programs received a 6-year “Next General Review” (NGR) decision in the 2008-2009 cycle. Statistics identifying the criteria involved in the accreditation decision are not published. However, from the author’s experience as a program evaluator, the overwhelming number of short-comings lie in criteria 2, 3 and 4—the formulation and assessment of outcomes and objectives, and continuous improvement, which is typically based on the results of assessment of outcomes and objectives. To address the challenge of assessment, uncomplicated methods of developing
outcomes and objectives, and straightforward, easy-to-comprehend methods of assessment would benefit both the novice as well as those who have been struggling with the ABET assessment process for a while. In particular, to maintain a truly sustainable continuous quality improvement process, buy-in from faculty is necessary and simple assessment processes contribute significantly to acceptance and support by the individuals who are responsible for program assessment.

In this paper we present streamlined, straightforward procedures for developing program educational objectives and program outcomes, and focused and effective methods of assessment. Three case studies are presented, as well as lessons learned while employing the procedures. We have found that following the processes presented herein results in an sustainable assessment plan that is straightforward to implement and easy for faculty to comprehend.

II. Definitions and Constraints

To set the stage for the procedures and assessment methods to be presented, definitions and governing constraints for objectives and outcomes as prescribed by ABET are provided.

A. Program Educational Objectives

ABET defines program educational objectives as “broad statements that describe the career and professional accomplishments that the program is preparing the graduates to achieve.” In Criterion 2 Program Educational Objectives, ABET also prescribes that “each program for which an institution seeks accreditation must have in place: (a) published educational objectives that are consistent with the mission of the institution and these criteria [as described in the document], (b) a process that periodically documents and demonstrates that the objectives are based on the needs of the program’s various constituencies, and (c) an assessment and evaluation process that periodically documents and demonstrates the degree to which these objectives are attained.” In simple terms, program educational objectives describe the final goal of an engineering program, which is to develop competent engineers who are equipped to fulfill their responsibility to their employers and society. The process of establishing those goals must include input from those the program serves and assessment must take place to demonstrate that the program is achieving those goals.

B. Program Outcomes

As defined by ABET, “Program outcomes are narrower statements that 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 student acquire in their matriculation through the program.” In Criterion 3 Program Outcomes, ABET prescribes that “Program outcomes are (a) through (k) plus any additional outcomes that may be articulated by the program. Program outcomes must foster attainment of program educational objectives.” The criterion further states that, “There must be an assessment and evaluation process that periodically documents and demonstrates the degree to which the program outcomes are attained.” In essence, outcomes describe what engineering students should know and be able to do by the time they walk across the stage at graduation. Achievement of the outcomes will prepare students to function as competent employees and responsible members of society. As with the program educational objectives,
there must be an assessment process to demonstrate the extent to which students are achieving the outcomes.

C. Definition of Assessment and Evaluation
ABET defines assessment as “one or more processes that identify, collect, and prepare data to evaluate the achievement of program outcomes and program educational objectives.” Evaluation is defined as “one or more processes for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which program outcomes or program educational objectives are being achieved, and results in decisions and actions to improve the program.” As such, “assessment” is used to describe the process of gathering data, and the term, “evaluation” is used to interpret the meaning of the data and to determine what to do in response.

III. Developing Program Educational Objectives and Assessment

A. Requirements for Program Educational Objectives
A common issue cited by evaluators regarding program educational objectives is that they sound too much like ABET Criterion 3 Outcomes (a) through (k), and thus describe what students are expected to know and be able to do instead of career and professional accomplishments expected of graduates after a few years of employment. Statements that are too closely aligned with the outcomes can result when a program addresses the development process with the “answer” in mind. That is, since the attainment of the program educational objectives must be fostered by the program outcomes, those responsible for their development may view the task as merely one of combining and wordsmithing the outcomes into program educational objective statements, and then having constituents review statements for approval. Such an approach does not fully utilize the expertise of a program’s constituents who may then view their role as one of rubber-stamping the work of a small group of faculty. Herein we propose a process that begins without a preconceived notion of what the final product should look like, and allows constituents to take a more meaningful and creative role in developing program educational objectives.

To reiterate and paraphrase the governing constraints on program educational objectives, they must be (1) based on the needs of the program’s constituents, (2) consistent with the mission of the institution, (3) consistent with the ABET criteria for engineering programs, (4) published, (5) periodically assessed to determine the degree to which they are attained, and (6) periodically reviewed for currency with regard to the needs of the program’s constituents. In addition, (7) all relevant processes must be documented. A contingent constraint is that (8) attainment of program educational objectives must be fostered by the program outcomes.

B. Suggested Process for Developing Program Educational Objectives
A procedure that begins with a focus on the needs of the program’s constituents (1) and then addresses constraints (2) through (7) will be presented. The flowchart in Fig. 1 illustrates the procedure. The contingent constraint (8) will be addressed in Section IV.
Step 1. Convene Team of Constituents.
Gather a group of 12-20 of your constituents (alumni, industrial advisory board members, non-alumni stakeholders, employers, faculty, students, etc.). The meeting facility must allow for the group to split up into four smaller groups. Four easels or wall space suitable for sticking Post-it notes is required. Participants should plan for a full day (6-8 hours) of work, so have restrooms, snacks and lunch available. A location off-campus will help minimize distractions for faculty and student participants.

Step 2. Introduction.
Begin with an overview of the purpose of the meeting and a brief discussion of ABET accreditation requirements and assessment processes. Provide the definition of program educational objectives and explain that the purpose of the gathering is to develop statements for your program. Do NOT provide copies of previous statements, and do NOT provide copies of ABET program outcomes (a) through (k). The goal is for the resulting statements to be developed without a preconceived notion of what they should look like.

Step 3. Individual Session: Brainstorming.
Give each participant a pad of Post-it notes. Present the question, “What do you expect graduates of our program to attain within a few years after graduation?” Specifically, what professional skills, competencies, and accomplishments do you expect of graduates of your program 3 to 5 years after graduation? Tell participants to record each idea on a separate sheet. Emphasize creativity, and allow 15-20 minutes or until they exhaust ideas.
If you have key constituents who cannot attend the workshop, you should solicit input by email prior to the event. First, set the stage as described in Step 2 and then present the same questions asked of constituents at the workshop. The email responses should be copied on to Post-it notes and merged into the ideas presented by workshop participants in Step 4.

Divide participants into teams of three or four members, with each team representing a diversity of constituencies. The team members should present their ideas one at a time and post their notes on a flipchart or wall. The entire group should then discuss commonalities among ideas and group notes by theme. If some ideas are determined to be inappropriate, toss them out.

Step 5. Large Group Session: Review and Refine Themes.
Reconvene the entire team. Each small group then reports its findings and lists the themes they determined in their session. The entire team should discuss the commonalities and differences in the lists of group themes and combines, modifies, and refines them to determine a final list of unique themes to reflect the distinct professional skills, competencies, and accomplishments expected of program graduates after three to five years of employment. Most programs will find that they will have four to eight final themes.

Divide the team into three to five groups. Distribute the themes among these smaller groups with each group being assigned one to three themes for which it will draft program educational objectives statements. Provide each small group with all of the Post-it notes related to its assigned themes. For each theme, a group should review all of the related notes, compile a list of major components, and then draft a broad statement to encompass the theme. A bulleted list of descriptors of the major components should be included to provide specifics that further define the theme. An expanded version of each objective can be formed by appending an introductory phrase and the bulleted list. The list provides details that will facilitate assessment of program educational objectives. An example, the development of which is presented in Section VI, follows. The short version is formed by deleting the italicized text.

Step 7. Review Statements.
The draft statements should then be presented to entire team for comment and input, and modified as time allows. By the end of the session, your department will have draft educational objective statements, and the majority of the work is finished.

Step 8. Finalizing and Confirming Statements
After the workshop, the wording of the objectives statements should be refined, and the statements should be reviewed by the department’s ABET Committee to ensure that they are consistent with the mission of the institution and ABET criteria. At this point, it is advisable to review the old program educational objectives to ensure that no essential elements were omitted in developing the new statements. The refined version should be presented to additional constituents via email, to the department faculty at a faculty meeting and to the department’s advisory board for review and comment. If warranted, the statements should be modified in response to this additional feedback. The finalized statements are then presented to the department faculty for approval.
Educational Objectives for the Engineering Management Program at Missouri S&T

Graduates of the Engineering Management Program will exhibit proficiency and excellence in the areas of technology, finance, human relations, communications, and professional behavior. Within these areas of proficiency, graduates will exhibit the explicit skills and knowledge as detailed below.

Technical Knowledge and Analytical Problem Solving: Graduates of the Engineering Management Program are able to analyze and solve complex problems utilizing:

- a mastery of Engineering Management tools and techniques including those utilized in operations management, project management, Management of Technology and supply chain management
- in-depth knowledge in at least one emphasis area within Engineering Management
- an understanding of the fundamental principles and concepts of engineering
- sound business judgment
- relevant analytical and modeling tools such as statistics.

Finance: Graduates of the Engineering Management Program are responsible and financially aware managers and leaders who utilize basic finance, accounting, engineering economy and risk analysis methods to manage and identify the financial impact of business opportunities.

Human Relations: Graduates of the Engineering Management Program are competent leaders who develop and utilize the skills and abilities of teams and individuals within the organization as evidenced by proficiency in:

- team building
- conflict resolution
- efficient and effective management of constituents with diverse skills
- empowering teams and individuals through coaching and mentoring
- conducting effective and efficient meetings.

Communication: Graduates of the Engineering Management Program engage others through effective oral, technical and written communication evidenced by:

- active listening
- clarity and conciseness in presentation
- an ability to adjust content and presentation style to audience
- confidence and discernment in asking appropriate questions to obtain information vital to the project or task at hand.

Professional Behavior: Graduates of the Engineering Management Program will continually grow in their awareness and understanding of the societal, ethical, cultural, legal and political issues prevalent in an increasingly global society.

Integration: Drawing on proficiencies in the areas described above, Graduates of the Engineering Management Program are able to integrate their skills and knowledge to:

- effectively manage people, talent, time and financial resources
- develop successful marketing strategies
- develop plans for projects and programs
- analyze problems, consider alternatives, and implement solutions.

ABET requires the revised objectives to be published. Typically they are posted on the department’s website, printed in the university catalog and included in recruiting publications.
addition, the entire process of developing the program educational objectives should be documented. Save all notes and related materials in a binder for easy access and future reference.

C. Periodic Assessment of Program Educational Objectives.
Assessment methods based on an individual’s reflection on his or her abilities or achievement produce indirect assessment data, whereas observation or measurement of performance provides direct assessment data. While direct assessment provides a more objective evaluation of performance, ABET acknowledges that direct observation of alumni performance can be problematic. Therefore, alumni surveys provide an acceptable primary means of assessment for program educational objectives, with direct measures used to augment the indirect assessment data. In contrast, the primary assessment methods for program outcomes are expected to be direct measures; observation and measurement of student performance is much more tenable since faculty have ready access to students and regularly observe their work in courses.

In designing objectives assessment instruments, it is important to keep in mind that the goal of the assessment process is to gain information that is useful for program improvement. Therefore, assessment instruments must be designed so that the information obtained is at a level of detail such that shortcomings can be addressed. For example, suppose a program educational objective is that graduates of a program will be effective communicators, and assessment of that objective revealed that the program fell short of its goal. How could the program address the shortcoming? Since “effective communicator” is a broad term that includes giving presentations, running meetings, resolving conflict, writing technical memos, etc., more information is needed before effective measures can be taken to address the problem. In the process of developing objectives using the brainstorming method described above, the major components of each objective are itemized and provide details that are useful in developing assessment instruments.

The alumni survey presented in Fig. 2 evolved directly from the process of developing program educational objectives. The broad objectives statements are followed by the related components that lead to the formation of the statements. The alumni survey asks for respondents to rate their perception of how well the program prepared them to attain each component. Once an alumni survey is developed it is sent to the target alumni group, which is generally agreed to be those 3 to 5 years post-graduation. A survey schedule should be set up to avoid multiple responses from the same graduate. For example, every two years the instrument could be sent to all graduates who are four and five years post-graduation.

While the alumni survey is an effective indirect method of assessment, most program evaluators will expect also some direct assessment measures. Direct assessment of educational objectives is typically achieved through input from employers. Where feasible, educational objectives can be assessed by convening focus groups at the location of major employers. The assessment can be accomplished through a discussion prompted using items on your alumni survey. Alternately, you could hold a teleconference with key employers, or take advantage of the convergence of employers at career fairs and convene a focus group while they are in town.

Assessing objectives using employer surveys requires that programs maintain close contact with employers. However, many programs have graduates scattered across a wide spectrum of industries and have difficulty getting surveys to the appropriate individuals. Thus, while valuable
assessment data can be obtained if a program has access to individuals who directly supervise its graduates, this tool doesn’t work for all programs.

D. Periodic Review of Program Educational Objective Statements
Program Educational Objective statements should be reviewed every two or three years to ensure that they are relevant and current. It is not necessary to go through a process as extensive as described for the initial development. A review of the statements can be accomplished at a meeting of the program’s industrial advisory board, for example. Additional input can be obtained by convening employers while on campus for career fairs. Another method for periodic review is to include a means for alumni to indicate the level of importance of each component of the objectives when they complete the alumni survey.

E. Special Case: New Programs
The question naturally arises regarding what new programs should do to develop and assess program objectives. Since these programs are going through their first ABET review perhaps only 6-9 months after their first student has graduated, they have neither alumni who graduated 3-5 years ago, nor do they have an assortment of employers who can provide a direct assessment of the on-the-job skills and performance of such an alumni cohort. The way around this apparent obstacle is as follows.

First, you can still convene a group of constituents as described in Step 1 above, except that in this case there are simply no alumni or actual employers present. To complement the industrial advisory board members, non-alumni stakeholders, and faculty who are present, invite 3-4 potential employers of your students. Potential employers can be identified at career fairs or with the help of your industrial advisory board (which, actually, may itself already be comprised of potential employers of your program students).

Second, follow the 8-step process outlined in Section III.B above for the development of program educational objectives.

Third, develop an alumni survey as discussed in Section III.C above and shown in Fig. 2. Now, rather than sending the survey to a cohort of alumni who are 3-5 years out, send it to another group of potential employers with the request that they assess the appropriateness of the stated program objectives as skills and accomplishments that are reasonable to expect of graduates having been out in the workforce for 3-5 years.

In this manner, your assessment exercise is really a validation exercise whose results can be used to either confirm your initial set of program objectives or make some adjustments to them, based on input received from an independent set of reviewers. We followed this process in the establishment of the program objectives for our new architectural engineering program, and were pleased to see that our ABET review team deemed it to be an acceptable approach for a new program to follow.
Did the Engineering Management program enable you to achieve the following broad or specific objectives in your career progression?

<table>
<thead>
<tr>
<th>Department Educational Objectives:</th>
<th>Level of Agreement:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Technical Knowledge and Analytical Problem Solving:</strong> Graduates of the Engineering Management Program are able to analyze and solve complex problems utilizing:</td>
<td>Strongly Disagree Disagree Neutral Agree Strongly Agree</td>
</tr>
<tr>
<td>➢ A mastery of engineering management tools and techniques including those utilized in operations management, project management, management of technology and supply chain management.</td>
<td></td>
</tr>
<tr>
<td>➢ In-depth knowledge in at least one emphasis area within engineering management.</td>
<td></td>
</tr>
<tr>
<td>➢ An understanding of the fundamental principles and concepts of engineering.</td>
<td></td>
</tr>
<tr>
<td>➢ Sound business judgment.</td>
<td></td>
</tr>
<tr>
<td>➢ Relevant analytical and modeling tools such as statistics.</td>
<td></td>
</tr>
<tr>
<td><strong>2. Finance:</strong> Graduates of the Engineering Management Program are responsible and financially aware managers and leaders who utilize basic finance, accounting, engineering economy and risk analysis methods to manage and identify the financial impact of business opportunities.</td>
<td>Strongly Disagree Disagree Neutral Agree Strongly Agree</td>
</tr>
<tr>
<td><strong>3. Human Relations:</strong> Graduates of the Engineering Management Program are competent leaders who develop and utilize the skills and abilities of teams and individuals within the organization as evidenced by proficiency in:</td>
<td>Strongly Disagree Disagree Neutral Agree Strongly Agree</td>
</tr>
<tr>
<td>➢ Team building.</td>
<td></td>
</tr>
<tr>
<td>➢ Conflict resolution.</td>
<td></td>
</tr>
<tr>
<td>➢ Efficient and effective management of constituents with diverse skills.</td>
<td></td>
</tr>
<tr>
<td>➢ Empowering teams and individuals through coaching and mentoring.</td>
<td></td>
</tr>
<tr>
<td>➢ Conducting effective and efficient meetings.</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Portion of engineering management alumni survey illustrating use of extended version of educational objectives statements to facilitate assessment.

**IV. Developing Outcomes and Assessment**

**A. Requirements for Program Outcomes**

ABET defines program outcomes as (1) ABET Criteria 3 Outcomes (a) through (k), and (2) outcomes articulated by program. They must (3) foster attainment of program educational
objectives, and (4) be periodically assessed and evaluated to demonstrate the degree to which they are attained. A process to satisfy items (1) through (3) in developing outcomes is now presented followed by an assessment process that will address requirement (4). The flowchart in Fig. 3 illustrates this method of developing and assessing outcomes.

![Flowchart](image)

**Figure 3. Procedures for developing and assessing program outcomes.**

**B. Process for Developing Program Outcomes**

**Step 1: Begin With ABET Criteria 3 Outcomes (a) Through (k)**

In the early years of EC2000, program outcomes had to encompass the ABET-prescribed (a) through (k), but could not be taken verbatim from the ABET statements. Many departments went to great lengths to combine and reword (a) through (k), and then mapped them back into the original (a) through (k) statements as instructed in the ABET Self-Study Questionnaire. This exercise was frustrating and confusing to faculty, and the benefit of adding this step to the assessment process was unclear. ABET has since changed its practice and defines the common portion of the program outcomes as the prescribed (a) through (k), which can now be used verbatim. So, (a) through (k) form the foundation for your program outcomes, and they can be tweaked to better suit your program if your find that your program’s assessment process would be enhanced by modifying the wording. For example, ABET states the second outcome as follows: (b) an ability to design and conduct experiments, as well as to analyze and interpret data. The corresponding outcome for the engineering management program at Missouri S&T reads as follows: (b) an ability to design and conduct experiments related to operations, marketing, management and finance, as well as to analyze and interpret data. The change focuses
Step 2: Address Other Outcomes of the Program and/or Program Criteria

If your department wants to specify additional outcomes for your program, it may do so. Also, note that although Criterion 9 states that program criteria may only address faculty and curriculum, the wording of the program criteria for some programs parallels the wording for program outcomes (e.g., “apply knowledge of ...”). As we discovered in our recent accreditation visit, assessment of program requirements as delineated in program criteria will be expected by some program evaluators. Recent conversations with ABET leadership have confirmed that there is stated no requirement that a program must "assess" the requirements of program criteria in the same way that outcomes must be assessed as required by Criterion 3. For those programs whose lead societies used the word "demonstrate" in developing their program criteria, the issue quickly centers on what means or methods can or should be used to "demonstrate that students can …", for example, as required by civil engineering.

Of course, if a program chooses have one or more additional program outcomes built on program criteria curriculum requirements, then that program must address those outcomes as part of the "assessment and evaluation process" that is required in the last paragraph of Criterion 3. However, for a program that chooses not to incorporate specific program criteria curriculum requirements into their program outcomes, while it would still be valid to use data from their assessment and evaluation processes "to demonstrate that students can" do the things that are required by the program criteria, a program is not required to use this means for meeting program criteria requirements.

Given our recent experiences and the substance of our conversations with ABET leadership, we believe that until greater consistency in the expectations of program evaluators is reached, it is safer to treat curriculum requirements stated in program criteria as outcomes. Then, to address the curricular requirements stated in program criteria, first determine whether or not they are covered in your version of the (a) through (k) outcomes. If not, tweak the outcomes statements or add additional ones to ensure that assessment of your program criteria takes place.

Step 3: Program Outcomes Must Foster Attainment of Program Educational Objectives

Examine your program educational objectives to determine areas not covered by outcomes (a) through (k) or program criteria. For example, an educational objective for your program might be that graduates are leaders in their field, or that they work across cultures. To foster attainment of objectives such as these, the program may need additional outcomes.

B. Assessment of Outcomes

1. Requirements for Assessment of Outcomes

The final requirement for outcomes as specified by ABET is that “there must be an assessment and evaluation process that periodically documents and demonstrates the degree to which the program outcomes are attained.” ABET evaluators are looking for evidence that outcomes are being met and expect direct assessment to take place. As with educational objectives, outcomes must be assessed at a level of detail such that the information obtained is useful for program improvement. Thus, program outcomes, which are somewhat general in nature, can be broken
down into specific components commonly referred to in ABET assessment training sessions as “performance criteria.” A key to a sustainable assessment plan is to gather a reasonable amount of meaningful assessment data. If an assessment plan is developed strategically, as few as three to five meaningful direct assessment measures per outcome are adequate.

2. Suggested Procedure for Developing Direct Assessment Process for Outcomes

Step 1: Determine Performance Criteria for Each Outcome

As related to each outcome, determine two to five skills or competencies that the students in your program should have by the time of graduation. Express these skills or competencies using action verb to form performance criteria, e.g., “Communicates effectively in group oral presentations” or “Analyzes charts and graphs and incorporates information into decision-making process.” More examples are provided in Section VI.

Step 2: Determine Courses Where Performance Criteria Can Be Assessed

In deciding where to assess outcomes, bear in mind that each student going through your program must be provided opportunities to meet each outcome. Therefore, while elective courses may support the attainment of outcomes, it is much cleaner if assessment of all outcomes takes place in required courses. If there are electives for which students have a limited choice of courses, those courses can be used for assessment if the same performance criteria are assessed in each of the options. However, the complexity of that process increases dramatically as the number of options increases.

The ABET Self-Study Questionnaire lists information required for each course, which includes “the relationship of the course to program outcomes.” For each course to be used for assessment, ask the responsible faculty member to examine the list of program outcomes to determine which outcomes a given course supports, and also provide a brief description of what is done in the course (assignment, project, test question, etc.) to support the outcomes. Once this information is compiled, courses to use in assessing outcomes can be easily identified. As we discovered, for a given course a faculty member can complete the task of listing the outcomes supported by the course and provide a brief description of supporting activities in less than thirty minutes.

Once the supporting activities have been determined, identify a specific course or courses in which each performance criterion will be assessed. Note that there may be more than one possible course to use to assess some performance criteria. In selecting courses for assessing performance criteria, consideration should be given the appropriateness of the supporting activity for assessment, and the distribution of workload among faculty. Some activities may peripherally address the performance criterion, whereas others may provide a more robust treatment of the competency of interest. If there are outcomes with a smaller number of performance criteria, it is advisable to assess some of them with more than one tool (assignment, project, test question, etc.). For example, if an outcome has only two performance criteria, you could assess each one with two different assessment tools. Three to five direct assessment measures spread out over the performance criteria for each outcome should be the norm.

Step 3: Decide Assessment Tool for Each Performance Criterion

The skills or competencies addressed by some performance criteria may be assessed with a numerical scale, but rubrics are often more appropriate. For example, while a percentage of
correct answers to a quiz focused on computation might be appropriate to assess the performance criterion “Applies knowledge of statistics,” a rubric is a more suitable method of assessing “Communicates effectively in oral presentations.” A rubric breaks the performance criterion into categories for which levels of achievement are provided for assessment. For example, “Communicates effectively in oral presentations” can be broken down into organization, visual presentation, vocal delivery, and connection with audience. A sample rubric for this performance criterion is shown in Table 1.

Table 1. Rubric for Assessing “Communicates Effectively in Oral Presentations”

<table>
<thead>
<tr>
<th>Category of Assessment</th>
<th>Minimal Evidence</th>
<th>Below Expectations</th>
<th>Meets Expectations</th>
<th>Exceeds Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization</td>
<td>Little or no evidence of organization.</td>
<td>Presentation is difficult to follow. Main points and conclusion are unclear.</td>
<td>Presentation can be followed with relative ease. Main points are obvious.</td>
<td>Clear introduction. Main points presented and argued. Flow of argument is logical.</td>
</tr>
<tr>
<td>Visual Presentation</td>
<td>Little or no effort in developing presentation. Inappropriately dressed or disengaged.</td>
<td>Boring or confusing slides and/or props. Little effort in developing effective presentation.</td>
<td>Adequate slides and/or props. Visual presentation is reasonably effective.</td>
<td>Creative slides and/or props. Effort made to make visual presentation effective.</td>
</tr>
<tr>
<td>Connection with Audience</td>
<td>Makes little or no effort to look at audience or respond to questions.</td>
<td>Poor eye contact. Reads or stumbles through presentation. Poor responses to questions.</td>
<td>Appropriate eye contact. Some modification of delivery to audience reaction. Responds appropriately to questions.</td>
<td>Engages audience. Aware of audience reaction. Responds well to questions.</td>
</tr>
</tbody>
</table>

For this sample rubric, the instructor of the course would determine the level of performance of each student during his or her presentation. The raw data from the assessment would be recorded on a grid to indicate how many students fell into each of the four levels of performance for each of the four categories.

Step 4: Establish Metrics for Performance Criteria and Outcomes
After the method of assessment of each of the performance criteria is determined, set an acceptable level of performance (performance metric) for each performance criterion. For example, if numeric assessment is appropriate, the performance metric may be expressed as “80% of students will score at least 70%.” If rubrics are used, the performance metric is typically expressed in terms of percentage of students meeting or exceeding expectations, e.g., “for each category of a performance criterion, 75% of students will meet or exceed expectations.” A threshold should also be set for outcomes in terms of level of achievement on performance criteria, e.g., “the outcome is met if metrics on four of the five performance criteria are met.”
Performance metrics should make sense with respect to your program and the level at which you are assessing students. For example, a program may choose to have higher metrics for performance criteria for outcomes that foster those objectives that are deemed more important by constituents, and the metric might be higher for a performance criterion that is assessed at the senior level than for the same performance criterion assessed at the sophomore level.

3. Indirect Assessment of Outcomes
If a second type of assessment process is desirable, senior exit surveys provide a relatively efficient method of obtaining indirect assessment data. Surveys can be designed using questions related to outcomes and performance criteria. Alternately, senior exit interviews can be conducted using the same types of questions.

4. Assessment Schedule
Programs do not have to assess every performance criterion every semester. A suggested schedule is to assess a performance criterion once a year as long as the metric is met. If the metric is not met, changes should be made and assessed the next time the course is taught. A good policy to establish is to require submission of assessment results from each course at the time course grades are due. It is desirable to establish an expectation for faculty such that submission of assessment data becomes a routine part of a course.

V. Evaluation and Continuous Improvement
Once the assessment data are collected and processed, they must be evaluated, i.e., interpreted to determine the extent to which objectives and outcomes are attained for the purpose of deciding actions to be taken to improve program.

1. Program Educational Objectives
The results of objectives assessment are used to determine if changes need to be made in the curriculum, in individual courses or in the program outcomes; or if other modifications need to be made in the program or assessment processes. It is also worth noting that modification in a program can be based on input not directly related to the assessment of objectives or outcomes. For example, industrial advisory board members may suggest a change in curriculum to keep pace with developing technology.

2. Program Outcomes
The data obtained through the assessment of outcomes should be evaluated to determine if changes should be made at the course level or the curriculum level, or if other changes are warranted. At the course level, an instructor can use performance criteria assessment data to determine if modifications are needed in the course or in prerequisite courses, e.g., a change in the method of presentation or assignments made, or the addition of course material. The data for all of the performance criteria for a given outcome should be consolidated and evaluated. Based on results for each outcome (including direct and indirect assessment), the department ABET committee should decide how to improve the program and the assessment process. As appropriate, outcomes or performance criteria may be added, modified or eliminated. Likewise, metrics may be changed if they are determined to be inappropriate.
3. Closing the Loop
After changes are made in the program, the effects of the changes must be assessed, a process referred to by ABET as “closing the loop.” While the effect of modifications made in response to outcomes assessment can be determined the within a year or so, assessment of the effect of changes in curriculum and courses on the career and professional accomplishments of graduates several years past graduation (i.e., pertaining to educational objectives) will have to be monitored over time.

VI. Case Studies

A. Development and Assessment of Program Educational Objectives for an Engineering Management Program
In March 2007, constituents of the engineering management program at Missouri S&T met in St. Louis to develop program educational objectives. The group consisted of four members of the Engineering Management Academy (all alumni of the program), one alumnus who had graduated within five years, the department chair, four faculty and two students. An additional academy member participated by teleconference, and four representatives of employers provided input by email. Program educational objectives were developed as described below.

1. The group was welcomed and an overview of the ABET assessment process was presented. The definition of program educational objectives was given and the group was told that the goal of the workshop was to develop objectives.

2. Participants were given pads of Post-it notes and were presented with the challenge to record the professional skills, competencies, and accomplishments that they expect of graduates three to five years past graduation. Participants spent about 20 minutes generating and recording over 150 ideas.

3. Four groups of 3 to 4 constituents each were formed. Each member presented his or her ideas and one group incorporated the ideas that were submitted by email prior to the session. The ideas were then grouped into themes.

4. The entire team then convened and each group presented its list of themes. Commonalities among the themes were discussed and it was determined that there were six distinct themes: technology and analytical problem solving, financial, people, communication, professionalism and big picture integration of the previous five elements.

5. The six themes were grouped into three pairs and each participant chose one pair of themes to work on, thus forming three groups. Each group was provided with all of the notes for their two themes and was charged with drafting statements to encompass the ideas related to each theme.

6. The entire team convened again and the educational objectives statements were presented for review and comments.
7. After the statements were presented and discussed, a conversation about the program ensued. Based on the newly-developed objectives statements, shortcomings in the program (i.e., absence of risk analysis and project management) were identified along with ways to address them.

Two versions of the program educational objective statements were drafted. The extended version captures more specifics and amplifies the details of short version of the statement. The details included in the extended version were incorporated into an alumni survey used in assessing the objectives.

Subsequent to the session, further iterations and refinements of the objectives were made with this core group through email. Finally, the statements were presented to the entire department faculty for additional refinement. Changes and comments were then shared with the original constituent group, and final faculty approval was received during the fall of 2007. The extended version of statements is presented in Section III.B. The short version is formed by deleting the italicized text.

Shortly following approval of the new educational objectives, an alumni survey was developed from the extended version of the statements. A sample portion of the survey, which addresses the first three objectives, is presented in Fig. 2. In spring 2008, the survey was sent to 260 graduates of the program who had graduated 3 to 6 years prior, and 44 surveys were returned. The target metric for all components of the objectives was “85% of respondents would ‘agree’ or ‘strongly agree’ that the program prepared them to achieve the specific objective in their career.” The survey results indicated that three of the specific objectives (modeling tools and statistics, conducting meetings and marketing strategies) had agreement percentages in the 70%-range, and two (conflict resolution and empowering teams) had agreement percentages of 84%, just short of the acceptable mark. As the department was already undergoing a major curriculum revision in response to academy input, these five specific objectives are being addressed in new and modified courses.

B. Development and Assessment of Program Outcomes for Engineering Management Program

Program outcomes for the engineering management program were developed from the original (a) through (k) list by making a few minor edits in the wording to better reflect the personality of the program.

No outcomes were added based on the program criteria or educational objectives, as the addition of the descriptor “engineering management” to the (a) through (k) statements was deemed to encompass the list of additional requirements. To be noted is that these outcomes were developed before the list of design constraints was added to outcome (c), but that outcome will be modified in the near future to reflect that change.

Once the program outcomes were developed, the department ABET coordinators met with the faculty who teach the seven core (required) engineering management courses to identify where to assess each outcome. Once the courses and the outcomes-related activities within the courses were identified, performance criteria were written based on the activities already integrated into the course. In retrospect, it would have been preferable to write performance criteria first (as described in Section IV) and then identify the activities in the courses where the criteria could be
assessed, as the resulting performance criteria more closely reflect what is already being done in the courses as opposed to what should be done. As a first attempt, however, the performance criteria fairly accurately represent the essential components of the outcomes for the program. The outcomes, with modifications in bold, and the related performance criteria are shown below. Additions to ABET outcomes (a) through (k) are in bold.

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**Program Outcomes and Performance Criteria**

**for Engineering Management Program at Missouri S&T**

(a) Engineering Management graduates will have an ability to apply knowledge of mathematics, science, and engineering in the solution of Engineering Management problems.

a.1 Creates and analyzes quantitative charts and graphs and incorporates information into managerial decision-making systems.

a.2 Identifies and uses appropriate modeling tools in the solution of quantitative problems.

a.3 Applies quantitative models to specific problem categories and classifications.

a.4 Uses a firm’s accounting system in making management decisions.

a.5 Uses financial ratio analysis, financial forecasting, valuation of assets, time value of money, capital budgeting and cost of capital concepts to solve engineering management problems.

(b) Engineering Management graduates will have an ability to design and conduct experiments related to operations, marketing, management and finance, as well as to analyze and interpret data.

b.1 Designs an operation system and analyzes and interprets data relative to the designed system.

b.2 Analyzes operational and financial data of organizations in case studies and organizational profiles.

b.3 Conducts research related to publicly traded firms and applies financial tools to evaluate the firm as a possible investment choice.

b.4 Analyzes organizational structure and understands origin of organizational culture and mechanisms of communication within organization.

(c) Engineering Management graduates will have an ability to carry out the design of an operational system and its various components and processes for Engineering Management applications.

c.1 Uses data from accounting systems for the purpose of analysis and design of managerial reports.

c.2 Identifies operational problem and design solutions to the problem using the appropriate quantitative and qualitative models and methods.

c.3 Designs and critiques a marketing plan with typical components, while recognizing intra-firm involvements and implications.

(d) Engineering Management graduates will understand the importance of teams, know how to develop effective teams and have an ability to function on teams.

d.1 Actively participates in and contributes to team assignments.

d.2 Recognizes when a team approach to a problem is preferable to an individual approach, forms team and evaluates effectiveness of team.

(e) Engineering Management graduates will have an ability to identify, formulate, and solve Engineering Management problems.

e.1 Develops model for making management decisions.

e.2 Identifies and analyzes engineering management problems related to case studies, current events, and real-life scenarios, and recommends solutions to problems.

(f) Engineering Management graduates will have an understanding of professional ethical responsibility.

f.1 Identifies an ethical dilemma and suggests a general course of action.

f.2 Selects and correctly applies an ethical model for decision-making in a moral dilemma.

f.3 Recognizes far-reaching implications of ethical behavior with respect to all organizational stakeholders.
Engineering Management graduates will have an ability to communicate effectively individually and in teams.

g.1 Effectively communicates in oral presentations.
g.2 Demonstrates proficiency in communication through team presentations.
g.3 Demonstrates command of the written and spoken word in required technical reports and presentations.
g.4 Analyzes and appreciates professional writing.
g.5 Understands impact of how differences in communication styles can lead to barriers in communication.

Engineering Management graduates will have the broad education necessary to understand the impact of engineering and enterprise solutions in a global and societal context.

h.1 Understands concept of Corporate Social Responsibility and can give examples to illustrate concept.
h.2 Effectively analyzes case and determines the impact on all stakeholders.
h.3 Comprehends pertinent issues in global marketing and the impact of these issues on marketing decisions.
h.4 Demonstrates understanding of the impact of technology solutions to society.

Engineering Management graduates will recognize the need for and have an ability to engage in life-long learning.

i.1 Recognizes benefits of continued learning through attendance at professional presentations and through reading professional publications.
i.2 Reads, analyzes and reports on scholarly research outside of the domain of engineering, science and management.
i.3 Identifies, reads about, analyzes and reports on “world view” issues that are opposed to own view.
i.4 Demonstrates appreciation for role of professional development in successful organizations.
i.5 Demonstrates appreciation for and involvement in continuing professional development in successful organizations, with demonstrated application to outside class resources.

Engineering Management graduates will have knowledge of contemporary issues related to Engineering Management.

j.1 Demonstrates awareness of, knowledge of, and respect for contemporary issues in engineering management, business and economics.
j.2 Recognizes the validity of cultural diversity as related to consumer behavior.

Engineering Management graduates will have an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

k.1 Utilizes electronic resources to acquire external data to solve engineering management problems.
k.2 Understands and utilizes computerized accounting systems to solve engineering management problems.
k.3 Uses Excel financial functions to solve time value of money problems.
k.4 Uses Excel in the solution of operational problems.

C. Development Program Outcomes for a Civil Engineering Program, Including Program Criteria

The program criteria for civil engineering provide opportunities for both tweaking original program outcomes as stated in (a) through (k) and for adding additional ones. The first ABET-prescribed outcome is “(a) an ability to apply knowledge of mathematics, science and engineering.” The civil engineering program criteria state, in part, that “the program must demonstrate that graduates can apply knowledge of mathematics through differential equations, calculus-based physics, chemistry and at least one additional area of science, consistent with the programs educational objectives.” This portion of the civil engineering program criteria can
fairly readily be incorporated into the ABET-prescribed outcome (a) by including the specifics related to math and science.

The civil engineering program criteria also include the requirement “that graduates can explain basic concepts in management, business, public policy and leadership.” While it might be possible to incorporate these concepts into the original (a) through (k) list of outcomes, this requirement deviates enough from the outcomes list that the addition of one or more separate outcome statements covering this requirement is warranted. As a result of feedback received from an ABET visit team, the civil engineering program established the following program outcome for its students. Also listed is the assessment tool and performance metric for each of the performance criteria under this additional outcome that stem from this program criteria curriculum requirement.

**OUTCOME 14:** Missouri S&T civil engineering program graduates should be able to explain basic concepts in management, business, public policy, and leadership.

<table>
<thead>
<tr>
<th>Criterion 9 Aspect</th>
<th>Assessment Tool, CE Program Course</th>
<th>Performance Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic knowledge of...</td>
<td>Management concepts – estimating &amp; scheduling</td>
<td>Estimating and scheduling exams, CE 248(1)</td>
</tr>
<tr>
<td></td>
<td>Business concepts</td>
<td>Consulting, contracts, and ethics exam, CE 248(1)</td>
</tr>
<tr>
<td></td>
<td>Public policy concepts</td>
<td>Graded assignments on environmental policy, CE 261(2)</td>
</tr>
<tr>
<td></td>
<td>Leadership concepts</td>
<td>Leadership exercise, CE 210(3); CATME(4) survey, CE 298(5)</td>
</tr>
</tbody>
</table>

(1)CE 248 – Fundamentals of Contracts and Construction Engineering  
(2)CE 261 – Fundamentals of Environmental Engineering and Science  
(3)CE 210 – Senior Seminar  
(4)Comprehensive Assessment of Team Member Effectiveness  
(5)CE 298 – Senior Design Project

**VII. Lessons Learned and Pitfalls to Avoid**

A. Developing Program Educational Objectives

To develop draft statements of program educational objectives in one session as described in this paper, the team of constituents must clearly understand the process and the definition of objectives, and be willing to embark on the process with an open mind. As discovered by a sister department using this process, a single team member can throw the process off-track by not engaging, or by pulling the conversation down a tangential path. It is recommended that the leader be someone who is knowledgeable with the process, but preferably not involved in the program so he or she can be more objective. In addition, the leader has to be organized and focused on moving things forward, and must be willing to intervene if necessary to move the process along. During the session, undue concern should not be put on exact wording or on an
objective that may seem off-base. Although the process of developing objectives must have constituent input, ultimately the program is responsible for the objectives, so problematic issues can be addressed later. Finally, in writing the statements, keep in mind that they are to be worded in terms of graduates of the program, not students.

B. Creating a Sustainable Assessment Schedule
A frequent response of faculty to the assessment of student outcomes is concern and fear that the process will be too time-consuming and difficult, or that coordinating the efforts for a department is a full-time job. These concerns may be valid if a program attempts to assess too much and too often with the hope that collecting a mound of data will cover all the bases. This unfocused approach is not sustainable, and results in waning faculty support.

As outlined in this paper, a reasonable and sustainable assessment program is possible if the program’s assessment plan is focused and deliberate. Program educational objectives can be assessed every 2 to 3 years with an alumni survey and by taking advantage of opportunities to receive input during advisory board meetings and from interaction with employers. Assessment of every performance criterion for every outcome every semester for every student is not necessary. A reasonable schedule for assessing performance criteria is once per year, which will establish a routine for faculty. If more than one section of a course is taught, assessment of students in one section is acceptable as long as the section is a representative sample of the students in the program. A plan that has proven to work well for programs is to require faculty to submit assessment data at the time grades are submitted. Evaluation of results at the end of the spring semester provides time for implementation of changes in courses in fall.

C. ABET Is In Flux
As most programs are aware, ABET assessment requirements have been undergoing significant and continual change since the EC2000 was implemented. Definitions and expectations have changed considerably over the past ten years and will continue to change. For example, as cited previously, initially programs were not allowed to use outcomes (a) through (k) verbatim, but now that is an acceptable practice. During the initial accreditation visit for our architectural engineering program in 2005, the advice given for assessing outcomes was that one direct assessment measure per outcome was sufficient. Now it is recommended that three to five direct measures be used. As we recently discovered, outcome (c) for our engineering management program will need to be revised to include the list of constraints that were added to ABET outcome (c) since we developed our outcomes. At the time this paper is being written, in fact, revised definitions for program educational objectives, program outcomes (soon to be termed “student outcomes”), assessment and evaluation presented in Section II are out for a two-year review as a part of the ABET harmonization effort to establish greater consistency across the four ABET commissions. It is the responsibility of programs to stay informed regarding changes in criteria and expectations for assessment by checking the ABET website and attending workshops. And, particularly until program evaluators achieve consistency in their expectations, it is advisable to obtain more than one opinion when uncertainties arise.

D. This Is Not Rocket Science!
Lastly, remember that the assessment and continuous improvement processes do not have to be complicated and onerous. Draft statements for educational objectives can be developed within a
day. Program outcomes can be written in one to two hours. Writing and tweaking performance criteria takes two to six hours, and the time can be reduced by taking advantage of examples on the web. Identifying courses and instruments for assessment can be accomplished in a one-hour meeting with faculty. Once faculty are familiar with the process, a rubric can be drafted in about 30-60 minutes and, again, there are excellent examples on the web to use for guidance. After a system is set up and the process is understood, the on-going assessment and reporting tasks take minimal effort on the part of the general faculty in a department, and the program coordinator will only spend about a day’s worth of effort annually compiling the data for review. So, although it takes thoughtful effort to put an effective plan into place, once the plan is established the work required to implement and sustain it need not be burdensome.

Bibliography

1. Gloria Rogers, Associate Executive Director of Professional Services, personal communication, August 2009.


4. Dayne Aldridge, Adjunct Accreditation Director for Engineering, personal communication, August 2009.