Developing a Sustainable Assessment Plan for EAC-ABET Accreditation

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ABSTRACT

Assessment is a critical component of the EAC-ABET accreditation process. While the task of assessment can initially be daunting, the process can be streamlined into a few key steps that can make this process simpler and more sustainable to either maintain or obtain accreditation. This paper will present methods and procedures to develop an assessment plan for any engineering program. Important topics discussed will include outcomes assessment, development of performance criteria for each outcome, rubric design, and examples of how all of these tie into an assessment plan.

Keywords: Accreditation, ABET, assessment, outcomes, engineering

1. INTRODUCTION

Program assessment is a critical component of attaining accreditation through the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC-ABET). In 2000, ABET adopted what was at the time a revolutionary approach to the accreditation of engineering programs through implementing outcomes assessment. The purpose of this change was to focus on what students were learning as opposed to what students were being taught (ABET, 2011). While the ABET criteria has been modified since that time, the concept of outcomes assessment has remained.

In their accreditation criteria, ABET provides the following definitions for outcomes and assessment:

- 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 (ABET, 2012).
- 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. (ABET, 2012).

ABET does not provide a specific definition of "direct" or "indirect" assessment, however Gloria Rogers effectively defines direct assessment as "Direct examination or observation of student knowledge or skills against measurable learning outcomes", and indirect assessment as "A process to ascertain the perceived extent or value of learning experiences" (Rogers, 2006). In other words, direct assessment is using a specific student artifact, such as an exam or report, and assessing against a set of criteria. Indirect assessment may include responses to a survey or questionnaire to determine a "perception" of how well a student achieved a certain outcome.

Ultimately, the determination of where, how, and when to assess the target student outcomes is the responsibility of each individual engineering program seeking accreditation. To be effective, the assessment plan must meet the ABET criteria as well as be sustainable for the faculty members performing the assessment. With a thorough understanding of the ABET criteria, proper planning, and focused assessment, this can be accomplished.

2. ABET OUTCOMES AND PERFORMANCE CRITERIA

In their criteria for the accreditation of all engineering programs, ABET prescribes a well-known list of expected students outcomes, commonly referred to as the "a through k" outcomes. ABET allows programs to use additional outcomes; however, it is required that the "a through k" outcomes are used and assessed by each program. It is important to note that while a list of prescribed outcomes is given, each individual program determines the method of assessing the outcomes. It is within these individual methods of assessment where each program can identify its individual characteristics through the types of materials collected and assessment methods used.

The first step in the assessment of outcomes is to define "performance criteria" for each outcome. Performance criteria are those specific things that the students must do to demonstrate they have achieved the outcome. The following is a list of the ABET "a through k" outcomes (ABET, 2012) along with the performance criteria developed for each outcome in the Civil Engineering program at Western Kentucky University (WKU CE).

(a) an ability to apply knowledge of mathematics, science, and engineering
- Prepare the appropriate physical model of the problem
- Apply and perform the correct mathematical analysis
- Present the final result in the appropriate manner
- Apply a logical process to the solution of problems

(b) an ability to design and conduct experiments, as well as to analyze and interpret data
- Perform the experiment and/or collect the data in accordance with the applicable standard,
- Perform the necessary calculations or data reduction to achieve the desired result,
- Apply the results to a practical situation
- Present the results in a professional manner

(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
- Complete a design project with clearly defined objectives, engineering standards, and realistic constraints.
- Select the appropriate analysis techniques and correctly complete the analysis
- Consider the non-technical issues in the design process and final solution
- Consider alternatives in the design process and select the best alternative
- Present solution in a clear, professional manner

(d) an ability to function on multidisciplinary teams
- Productive use of team time,
- Development of ideas as a team,
- Participation and support of team decision making process,
- Accountability,
- Encouragement,
- Assistance to others
- Overall team effectiveness.

(e) an ability to identify, formulate, and solve engineering problems
- Fully identify the engineering problem including applicable standards and constraints
- Prepare the appropriate physical model of the problem
- Apply and perform the correct mathematical analysis
- Present the final result in the appropriate manner
- Apply a logical process to the solution of problems

(f) an understanding of professional and ethical responsibility

Professionalism

- Complete assigned tasks in a timely fashion
- Present work in a clear, clean, precise manner
- Behave in an appropriate manner in professional contexts.

Ethical Behavior

- Recognize an ethical dilemma
- Identify those impacted by the dilemma
- Discuss the consequences of alternatives for resolution
- Develop an appropriate resolution
- Apply engineering codes of ethics to practical situations

(g) an ability to communicate effectively

- Demonstrate effective written communication skills – Organization, content, grammar, appearance, and format
- Demonstrate effective oral presentation skills – Organization, content, multi-media, body language, appearance, and delivery

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

- Demonstrate respect for diversity of peoples, ideas, and cultures. To achieve this performance criteria, students will listen critically and understand the viewpoints of others with differing political, cultural, or moral viewpoints
- Demonstrate knowledge of the responsibilities of an engineer in a global society
- Demonstrate awareness that engineering solutions can sometimes have cultural consequences

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

- Participation in professional development, professional society activities, and/or programmatic extracurricular projects
- Progression towards professional licensure or certification
- Ability to analyze the knowledge and skills needed at the beginning of a project and develop strategies for acquiring the missing knowledge and skills

(j) a knowledge of contemporary issues

- Discuss contemporary issues and offer insight into the issues as they relate to the engineering profession.
- Demonstrate a depth of knowledge of a major contemporary issue and offer insight into its impact on society as a whole
- Defend a position on a controversial contemporary issue.

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

- Select and use appropriate software tool for a given application.
- Use outside resources to advance a solution or improve upon an already acceptable solution.
- Use laboratories appropriately, safely, and in a way that enhances solutions to problems or completion of a project.

In the development of performance criteria, it is important to use "assessable" words in these criteria such that they can be assessed properly. Blooms taxonomy (Anderson et al, 2001) is an excellent resource for selecting the appropriate terms to use in the performance criteria to capture the type of information to be assessed.

3. WHERE TO ASSESS

With the performance criteria established for each outcome, the next step in the process is to determine where and how to assess the outcomes. It is generally a good idea to target at least one direct and one indirect assessment tool for each outcome. Table 1 shows examples of both direct and indirect assessment.

Table 1: Direct and Indirect Assessment Tools

Direct Assessment Methods	Indirect Assessment Methods
Class Exams	Student perception surveys
Written Lab Reports	Focus groups
National Standard Tests (FE)	Employer and/or alumni surveys
Written student self-reflection on what they have learned	Graduate school placement rates
Focus groups evaluating student work	Senior exit interviews
Evaluation of a performance or oral presentation	

A significant component of any assessment plan is the collection of the student work. To develop a sustainable assessment plan, it is important to be strategic with the quantity of work collected. If too much student work is collected, the process will become unsustainable. If too little work is collected, a negative result from the ABET visiting team could result. To determine what student work to assess, consider the following items:

1. Outcomes describe what students are expected to know and be able to do by the time of graduation, therefore, focus collection of student work on senior level courses taken by all students (avoid elective courses as they may not represent the entire student cohort). While many of these skills are taught throughout the curriculum, the focus of assessment is what the students have learned at the time of graduation.
2. Don't double assess. If a particular set of exams completely assess all of the performance criteria for an outcome, don't collect two sets of exams simply for the sake of more data. If students demonstrate they can do design in one course, then it follows they can do design in another course.
3. Target student work that can be used to assess multiple outcomes. A written lab report is very effective at assessing both outcome (b) performing an experiment, and (g) written communication.

Table 2 shows the assessment schedule for the WKU CE program for each outcome. Each assessment tool is shown as direct assessment (D), indirect assessment (I), and/or an assessment tool used in multiple locations (*). There are seven unique pieces of student work that are either collected or viewed, and most are used to assess more than one outcome. Data from the FE exam is used to assess multiple outcomes and is readily available from NCEES. Each year the senior class is given a survey where they provide feedback on their perception as to how well they have achieved the outcomes. Every three years a focus group of local Professional Engineers is gathered for an afternoon and they review and evaluate samples of student work. Typically, one member of the focus group is on the State Board of Engineers and Land Surveyors.

One assessment tool of note is the use of a debate to assess outcomes (h) and (j), which are often referred to as the "soft skills" outcomes. The students are broken up into teams of 3 to 5 and are provided with a contemporary issue that has a controversial component to it. The teams then debate each other taking either the "pro" side or "con" side of the issue. Each team is required to present their argument in a professional style oral presentation utilizing multi-media. Once each team has presented, they are given a 15 minute window to prepare a rebuttal argument. This technique has proven very effective in the assessment of the soft-skills outcomes.

When an assignment, paper, or presentation is to be used in the assessment process, the experience of the WKU CE program faculty is that it is imperative that the assignment given to the students clearly articulates the expected deliverables. For example, when the students are presented with the debate assignment, the performance criteria from outcomes (h) and (j) are clearly stated as items that must be covered during their presentation. While this may appear somewhat leading for the students, it in fact provides them a guideline for their presentation and gives them an opportunity to demonstrate clearly whether they have attained the desired outcome or if this is an area of improvement for the faculty.

Table 2: Assessment Schedule for the WKU CE Program

Outcome	Assessment
(a)	CE 410 Soil Mechanics - Exam (D) CE 382 Structural Analysis - Exam (D) FE Exam Data (D) Senior Survey (I) Focus Group (D)
(b)	CE 411 Soil Mechanics Lab - Report (D) A question from a CE 410 Soil Mechanics exam on designing a testing protocol for a project (D*)
(c)	CE 498 Senior Project - Final Report (D) CE 461 Hydrology - Project Report (D) Senior Survey (I*) Focus Group (D*)
(d)	CE 498 Senior Project - Final Report (D*) CE 498 Peer Reviews (I) Senior Survey (I*) Focus Group (D*)
(e)	Same as (a)
(f)	CE 400 Senior Seminar - Ethics paper (D) FE Exam (D*) Senior Survey (I*)
(g)	CE 411 Soil Mechanics Lab - Report (D*) CE 498 Senior Project - Final Report (D*) CE 400 Senior Seminar - Contemporary Issues Debate (D) Senior Survey (I*) Focus Group (D*)
(h)	Completion of WKU General Education Requirements (I) CE 400 Senior Seminar - Contemporary Issues Debate (D*) Senior Survey (I*) Focus Group (D*)
(i)	Percent of students taking the FE exam (I) Percent of students attending ASCE student chapter meetings (I) A faculty evaluation of students in CE 498 Senior Project and their ability to apply new skills (D)
(j)	CE 400 Senior Seminar - Contemporary Issues Debate (D*) Senior Survey (I*)
(k)	CE 498 Senior Project – Final Report (D*) CE 461 Hydrology – Project Report (D*)

4. HOW TO ASSESS

The most common method of assessment is with rubrics. To assess student work, the rubric should contain the following elements (Herman et al., 1992):

- One or more traits or dimensions that serve as the basis for assessment
- Definitions and examples to clarify the meaning of each trait
- A scale of value to rate each dimension

Craig Mertler has used these elements to develop a template that can effectively be used to assess the a through k outcomes (Mertler, 2001). Table 3 is an example of this template as used by the WKU CE program to assess outcome (a).

Table 3: Outcome (a) Scoring Rubric

Performance Criteria	**4 Exemplary**	**3 Proficient**	**2 Apprentice**	**1 Novice**
Physical Model	Applies correct concepts to formulate model with no errors	Applies correct concepts with only a minor procedural error	Applies correct concepts, but several procedural errors	Applies incorrect concepts, contains multiple procedural errors
Mathematical Analysis	Applies correct mathematical concepts with no errors	Applies correct mathematical concepts with only a minor error	Applies correct mathematical concepts, but contains a few errors	Applies incorrect mathematical concepts
Final Result	Final result is correct and presented in the most appropriate format	Final result is correct, presentation of answer is generally appropriate	Final result and/or presentation reflect noticeable errors	Final result incorrect and answer presented inappropriately
Apply a Logical Process	Solves problem using logical and efficient procedure and obtains correct solution	Solves problem using logical procedure and obtains correct solution	Solves problem using a logical procedure but makes procedural errors resulting in incorrect solution	Solution difficult to follow or is wrong, solution is incorrect

All of the rubrics used by the WKU CE program use a 4-point scale based on research performed by Dr. Robert Marzano (Marzano, 2006). The advantages of this scale are that they adequately provide the results needed for assessment without being too elaborate or cumbersome. In every case, the rubric is designed such that a score of 3 is the target acceptable value. When the average score for any performance criteria falls below 3, a plan for improvement is developed by the faculty.

As stressed by Dr. Marzano, assessment should not be used interchangeably with grading. The purpose of grading is to provide an individual student a grade or score based on their performance. Assessment attempts to identify strengths and weaknesses of a group of students. For example, a group of student exams results in an average score of 80. This result may be interpreted as indicating an acceptable level of performance of the group. However, an assessment of the exam may result in the discovery that most of the students missed the same question or made the same mistakes. This level of assessment would allow the assessor to evaluate that data and make the necessary improvements.

The scope of this paper does not allow for an example rubric for each outcome. However, using the example provided and a set of performance criteria, a draft rubric for each outcome can be developed and tested. It is important that the rubrics are tested to verify they are providing the necessary information. The goal of the ABET outcomes assessment process is to provide an avenue for continuous improvement, and continuing to improve the assessment process in addition to the educational experience of the student is part of that goal.

5. WHEN TO ASSESS

The frequency of assessment is also an important factor in developing a sustainable assessment plan. Initially, the WKU CE program set a 3-year assessment cycle. The plan was to collect the necessary student work over the course of the 3 years, and do a full assessment at the end of that cycle. Because the maximum length of accreditation ABET grants is 6 years this would essentially be a "mid cycle" assessment and a "full cycle" assessment (and of course, with some optimism this would be achieved). It seemed that this process would be sustainable with the work focused on the 3-year cycle. In practice, however, this proved to be ineffective. At the end of the 3-year cycle, data was frequently missing, not assessed, or simply forgotten. For the data that was available, faculty had to re-learn the process, assess work that may be 2 to 3 years old, and often found the rubrics no longer applicable or confusing. In addition, this provided only one opportunity to implement "continuous improvement" steps as a result of the assessment in between accreditation visits.

In 2010, it was decided to perform most of the assessment continuously. Most of the courses taught in the CE program are delivered once per academic year. The student work to be assessed as shown in Table 2 is collected each time that particular course is delivered. At the beginning of each semester, the CE faculty meet to go over what items need to be collected and assessed that semester. The faculty member responsible for the course then collects and assesses that work. At the end of each semester, the faculty spend a work day evaluating the results, and determining any continuous improvement steps necessary. All of the student work assessed is scanned and stored digitally, and the assessment data is stored in a master assessment file.

The exception to annual assessment is the focus group. This group is convened every 3 years to review student work from the previous year. Ideally this would be done annually, however it was concluded that being in a small community with a limited number of available PE's to perform the assessment, a 3 year cycle was more sustainable for the members of the focus group.

The results of performing this work annually are positive. Assessment has become a part of the regular routine of the faculty, it is actually less time consuming, and continuous improvements are much more effective and in line with the intent of the ABET criteria.

6. CONCLUSION

The process of outcomes assessment to achieve EAC-ABET accreditation does not need to be an overwhelming, complex task. This paper has outlined a step-by-step process with specific examples to develop an effective, sustainable assessment plan. The key elements of this process are:

- Understanding ABET assessment terminology
- Developing a set of performance criteria for each outcome that define what a student must demonstrate to show achievement of the outcome
- Thoughtful determination of a minimum set of items to collect and assess that is sustainable and effective
- Design of rubrics based on the performance criteria
- Regular assessment of the work such that it becomes integrated into the everyday work of the faculty.

If these steps are implemented, an assessment plan that is effective and sustainable can become an asset of the engineering program and lead to successful accreditation.

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