ASEE's 123rd Annual • Conference & Exposition • New Orleans, LA • June 26-29, 2016

New Orleans JAZZED about Engineering Education

Paper ID #14518

Annual Documentation of Assessment and Evaluation of Student Outcomes Simplifies Self-Study Preparation

Dr. Zia A. Yamayee, University of Portland

Dr. Yamayee's current professional interests include outcomes assessment in engineering education; design in engineering education; engineering design methodologies; and application of design methods to electric power distribution, transmission, and generation. Dr. Yamayee's work to date has included projects in power system planning, maintenance scheduling, hydrothermal simulations, unit commitment, operational and financial impacts of integrating new technologies with power systems, probabilistic production simulations, and integrated resource planning. In recent years, he has authored a number of articles and has given numerous presentations on outcomes-based engineering curriculum development and the implementation of the ABET Criteria for Accrediting Engineering Programs.

His professional experience includes more than 33 years of university administration, teaching, consulting, and research, as well as five years of full-time work in industry.

Dr. Peter M. Osterberg, University of Portland

Dr. Peter Osterberg is an associate professor in Electrical Engineering at the University of Portland (Portland, OR). He received his BSEE and MSEE degrees from MIT in 1980. He received his Ph.D. degree in electrical engineering from MIT in 1995 in the field of MEMS. He worked in industry at Texas Instruments, GTE, and Digital Equipment Corporation in the field of microelectronics. His research interests are microelectronics, MEMS, and nanoelectronics.

Annual Documentation of Assessment and Evaluation of Student Outcomes Simplifies Self-Study Preparation

Abstract

Electrical Engineering (EE) programs seeking accreditation from the EAC of ABET must demonstrate that they satisfy eight general Accreditation Criteria, plus any program specific criteria. Two of the most challenging and debated criteria are: Criterion 3 Student Outcomes (SOs), and Criterion 4 Continuous Improvement (CI). At the University of Portland, to prepare our EE program for a successful accreditation review, we divided the six-year ABET accreditation cycle into three distinct phases; namely, the years before the Self-Study year (phase one), the Self-Study year (phase two), and the visit year (phase three).

During phase one of the accreditation cycle (2010-2014) a number of direct and indirect assessment methods were used to assess and evaluate Student Outcomes. The results were used to identify program improvements. The program faculty documented the results in annual assessment and evaluation reports. During the Self-Study year (2014-2015), we used the annual reports to prepare the Self-Study report. The annual reports also provide evidence that improvements to our EE program were based on assessment and evaluation of SOs as well as other inputs.

At the heart of our assessment program lies course-embedded assessment. The choice of courses for course-embedded assessment is guided by two principles: (1) each Student Outcome is assessed with student work in a benchmark course, and (2) only required courses, not elective courses, in the curriculum are selected as benchmark courses.

Assessment of a benchmark course is conducted with the following in mind: (1) assessment of student work measures the extent to which SOs are being attained, (2) it is not necessary to use all of the student work to assess an outcome, and (3) outcomes assessment is based upon student work and is guided by the grading of that work.

In this paper, the implementation of our course-embedded assessment method to a benchmark course is presented. EGR 360-Analysis of Engineering Data was selected as a benchmark course

for the EAC Student Outcome b (an ability to design and conduct experiments, as well as to analyze and interpret data).

A description of the process, data collection efforts, and analysis of the results in applying course-embedded assessment method to the benchmark course are provided. We believe the process presented in this paper can be beneficial to others in the engineering community as they address compliance of their programs with the Accreditation Criteria.

Introduction

In 1992, ABET invited academic, industry, and professional society leaders to participate in a review of the accreditation process, and the Accreditation Process Review Committee was formed. In 1996, after thousands of hours of work by hundreds of engineering professionals, the ABET Board of Directors approved a new set of criteria for engineering education, the Engineering Criteria 2000[1].

The new criteria provided more flexibility to individual programs, allowing engineering schools to be responsive to the needs of their students, as well as the mission of their institutions and programs[2,3,4,5]. Over the years, these criteria have evolved and improved to the current Criteria for Accrediting Engineering Programs[6].

Programs seeking accreditation from one of the four ABET Commissions (ASAC, CAC, EAC, and ETAC) must satisfy eight general Accreditation Criteria, plus any program-specific criteria[6]. Since the early days, the three most challenging and widely debated criteria have included:

- Criterion 2. Program Educational Objectives. PEOs describe what graduates are expected to achieve (attain) within a few years of graduation. A few years is generally interpreted to be 2-5 years after graduation.
- Criterion 3. Student Outcomes. SOs describes what students are expected to know and be able to do by the time of graduation.
- Criterion 4. Continuous Improvement. CI requires that program improvements should be based on assessment and evaluation of Student Outcomes, as well as other information gathered by the program.

The focus of this paper is the assessment and evaluation of Student Outcomes. Results of evaluation of Student Outcomes are used to identify improvements to courses and curricula. To make the assessment and evaluation process sustainable and less cumbersome, at our institution we assess half of the SOs each year. Every two years we assess all 11 Student Outcomes of the Criteria for Accrediting Engineering Programs[6].

This paper is organized as follows. First, an overview of the outcomes assessment process is presented followed by a description of direct and indirect assessment methods. Then, course-embedded assessment is described, followed by the assessment of EGR360-Analysis of Engineering Data course as an example. Finally, the paper is closed with a summary of assessment and evaluation of Student Outcomes and annual documentation of improvements based on assessment and evaluation.

Overview of the Outcomes Assessment Process

The purpose of assessment is to gather data that can be used to: (1) document the success of an educational program in assisting students to achieve desired outcomes, and (2) identify aspects of the program that may need improvement.

At our school, the relationship between the assessment instruments/methods and the Student Outcomes are determined by the faculty of each program. Many of the assessment instruments are used to assess and evaluate more than one Student Outcome.

A matrix, mapping the Student Outcomes against assessment methods used to assess each of the 11 ABET EAC Student Outcomes, is prepared by each program faculty. One common assessment method used by all programs is course-embedded assessment. Each program ensures that the courses in their curriculum address all 11 SOs. Assessment methods for Student Outcomes include both direct and indirect assessment methods.

Direct and Indirect Assessment Methods for Student Outcomes[7,8,9]

Student Outcomes are closely tied to the PEOs. In a general sense, students who achieve the abilities in the 11 ABET Engineering outcomes should be prepared to attain the PEOs a few years after graduation.

Several assessment methods, both direct and indirect, are used for measuring the degree to which Student Outcomes are being achieved and for continuously improving the program. Direct assessment methods require students to demonstrate their knowledge and skills, and provide data that directly measure achievement of expected outcomes. Indirect assessment methods, such as surveys and interviews, gather reflection about learning. These methods are likely to suffer from validity and reliability problems as individual perception of their actual performance may be difficult to candidly or accurately report. Therefore, it is important to use a mix of both direct and indirect assessment methods in the assessment and evaluation of Student Outcomes.

The three direct assessment methods we use are course-embedded assessment, senior design course assessment, and nationally standardized examinations (Fundamentals of Engineering Examination or Major Field Test) or a faculty administered comprehensive examination. The indirect assessment tool we use in the assessment of Student Outcomes is a graduating senior exit survey. Below are brief descriptions of these assessment methods:

- Course-Embedded (course-based) Assessments. These include projects, assignments, reflective essays, or exam questions that directly link to Student Outcomes and are scored using established criteria.

- Exams. Locally developed comprehensive exams or nationally standardized exams (FE Exam or Major Field Test).

- Capstone or senior-level projects provide evidence of how well students integrate and apply principles, concepts, and abilities into a culminating project. They are evaluated by faculty and/or external review teams. This is an effective assessment tool when the student work is evaluated in a standard manner that focuses on student achievement of the outcomes.

- Graduating senior exit surveys. These surveys ask the graduating seniors their opinion on how well the program prepared them with respect to the 11 Student Outcomes. As an indirect assessment method, the survey gathers the students' reflection about learning.

Course-Embedded Assessment: Purpose and Structure

We use Course-Embedded Assessment as a direct assessment method for measuring the extent to which Student Outcomes have been attained. We also use other direct and indirect methods for assessing Student Outcomes. Here, we focus on the course-embedded assessment.

Course-embedded assessment has two primary roles:

- Using student work to assess the extent to which each Student Outcome has been attained, and
- Providing data for developing and improving the programs.

The course-embedded assessment process also provides a means of documenting the assessment results and the effects of any course and program changes that follow from the process. We assess Student Outcomes on a two-year rotating schedule. Although some assessment activities are conducted every year, each group of outcomes receives primary attention during alternating years.

Not all courses in the curriculum are involved in course-embedded assessment. The choice of courses is guided by the following principles:

- Each Student Outcome will be assessed with student work in a course(s) termed "benchmark course(s)."
- Required courses in the program curriculum will be selected as benchmark courses. We chose this approach because all students take the required courses.
- Although a benchmark course will likely address multiple Student Outcomes, typically one or two of its learning outcomes will be designated for course-embedded assessment.
- Because Student Outcomes are assessed in two groups on a rotating schedule, the benchmark courses are organized and assessed in two alternating groups.

Course-embedded assessment is administered with the following factors in mind:

- Assessment of student work will measure the extent to which Student Outcomes are being attained and will provide useful information for making program improvements.
- Within a benchmark course, it is not necessary to use all student work to assess an outcome that has been designated

for the course. Some student work will be more appropriate than others for assessing a particular outcome.

- Outcome assessment instruments (i.e. student work) will be designed so that they are focused and easy to administer and evaluate.
- Outcomes assessment will be based upon student work and will be guided by the grading of that work.

Course-Embedded Assessment: The Process

The process outlined below is used for selecting benchmark courses, assessing the benchmark courses, and making recommendation for course and program improvement.

- The program faculty periodically articulate the Performance Criteria (Indicators) associated with each Student Outcome[8,9].
- The program faculty identifies the benchmark courses that will be used for assessing each Student Outcome.
- The instructor identifies the specific instruments (i.e. student work, such as homework assignments, classroom activities, projects, and exams) that will be used to measure attainment of the designated outcome.
- The instructor assesses the student work in the benchmark course and determines the extent to which the Student Outcome has been attained.
- At the end of the academic year, the instructors prepare Course Embedded Assessment Summaries for each of the benchmark courses that are receiving primary attention during that year. The summary should: (1) identify the Student Outcomes that are being assessed in the course, (2) include a list of the Performance Criteria for each Student Outcome that is being assessed in this benchmark course, (3) identify the assessment instruments, and (4) determine the extent to which a Student Outcome is attained. Grades on student work, for example, can be used as a measure of the extent to which an outcome is being attained.
  The summary should also state whether the course will be modified to improve the program and whether program faculty action is recommended to improve the curriculum.
- At the end of the academic year, the program faculty consider the assessments of that year's group of benchmark courses. In combination with other assessment instruments and evaluation measures, the faculty determines the extent to which each of that year's group of Student Outcomes is being attained and whether program changes are desired or

required.

Example: Assessment of Analysis of Engineering Data as a Benchmark Course

EGR 360-Analysis of Engineering Data course is used as a benchmark course for the EAC of ABET Student Outcome b (an ability to design and conduct experiments, as well as to analyze and interpret data).

In assessing the student work to determine the degree to which Student Outcome b is attained, we are using the following Performance Criteria (Indicators):

> Performance Criterion b.1- Analyze data to determine specified quantities, evaluated by exams and/or homework.
>
> Performance Criterion b.2- Interpret the results for correctness and precision or apply the results to a pre-assigned problem. Draw conclusions based on the results of the analysis, evaluated by exams and/or homework.
>
> Performance Criterion b.3- Understand and apply concepts of randomization in experimental design, evaluated by exams and/or homework.

Student work used in the assessment process will include exam problems and/or homework problems relevant to each of the above Performance Criteria (b.1-b.3). Below is a list of possibilities we considered for evaluating each Performance Criterion.

> Performance Criterion b.1- Students analyze data to determine characteristics such as mean, median, and standard deviation. Students determine the appropriate probability distribution to model a given problem. Exam and/or homework problems are used to gather data which will be used to determine the level of achievement of this Performance Criterion. Example exam problems would ask students to determine mean and standard deviation for a random sample, and apply the Central Limit Theorem to calculate probabilities.

Performance Criterion b.2- Students interpret the results of their analysis to arrive at a conclusion or decision. This Criterion can be evaluated with homework and/or exam problems. Students, for example, could be asked to specify the value of a test statistic and draw a conclusion based on a statistical hypothesis test.

Performance Criterion b.3- Students identify appropriate factors and response variables for a proposed experiment, and identify ways to minimize or control variability within an experiment. They can determine an appropriate null and alternate hypothesis for a given experiment. This Criterion can be evaluated by exam and/or homework problems. Students, for example, could be asked to identify factors that would introduce variability in replicating an experiment, such as the manufacture of a given product or the effectiveness of an experimental drug. Students could be asked to determine a null and alternate hypothesis for a given experiment and make appropriate conclusions based on random sample data.

Assessment of Performance Criteria b.1-b.3

For the assessment of all three Performance Criteria, grades on student exams and/or homework are used to determine the extent to which each Performance Criterion is met. The Scoring Scale below is used to establish the degree of attainment of a performance criterion.

Scoring Scale for the Assessment of Performance Criteria (Indicators):

Score = 4. Student work clearly demonstrates superior attainment of the Performance Criterion. A score of 4 represents a class average of 90% or above on the graded work.

Score = 2. Student work demonstrates adequate attainment of the Performance Criterion. A score of 2 represents a class average of 70%-89% on the graded work.

Score = 0. Student work demonstrates poor attainment of the Performance Criterion. A score of 0 represents a class average of less than 70% on the graded work.

Note: A class average below a score of 2 on a homework or exam would constitute a problem requiring faculty review.

Assessment and Analysis of Student Work for Student Outcome b

Assessment Data

To determine the extent to which Student Outcome b is achieved for the benchmark course, we tabulate the results of assessment for each of the above Performance Criteria (b.1-b.3).

Table: Assessment Results for the Performance Criteria

Performance Criterion	Source of Assessment	Average Grade (%)	Score on a scale (0-4)
b.1	Problem 4, Final Exam	74	2
b.2	Problem 5, Final Exam	93	4
b.3	Problem 8, Final Exam	80	2
Average		82	2.7

Degree of Achievement of Student Outcome b:

The scores (0-4) for Performance Criteria b.1, b.2, and b.3 are averaged to determine the extent to which student outcome b is achieved (see below).
Score for outcome b = (score for b.1+score for b.2+score for b.3)/3 = 2.7
Alternatively, we could convert the average grade in percentage to a score on the scale of 0-4 to determine the degree to which student outcome b is achieved. Using this approach, the score for outcome b is (82/100) x4=3.28.
Since using either approach the score for outcome b is higher than 2, we conclude that Student Outcome b is achieved at an acceptable level.

Continuous Improvement:

Based on the results of this assessment and evaluation, no changes were proposed for this course.

Summary and Concluding Remarks

Programs seeking accreditation from one of the four ABET Commissions must demonstrate that they satisfy eight general accreditation criteria, plus any program specific criteria. Two of the most challenging and debated criteria are: Criterion 3 Student Outcomes; and Criterion 4 Continuous Improvement. At our institution, to prepare a program for a successful accreditation review, we divided the six-year ABET accreditation cycle into three distinct phases; namely, the years before the Self-Study year (phase one), the Self-Study year (phase two), and the visit year (phase three).

During phase one of the accreditation cycle, which is the primary focus of this paper, a number of direct and indirect assessment methods were used to assess and evaluate Student Outcomes. The results were used for measuring the degree to which the Student Outcomes are being achieved and to identify program improvements. The program faculty documented the results in annual assessment and evaluation reports for use in preparation for the ABET visit.

This paper described the course-embedded assessment and its use in determining the achievement of SOs in the context of a sustainable continuous improvement process.

Continuous Improvement has emerged as one of the most important ABET criteria for accreditation. The primary inputs to this criterion are the results of assessment and evaluation of Student Outcomes.

The purpose of assessment and evaluation of SOs is to gather data that can be used to: (1) document the success of an educational program in assisting students to achieve desired outcomes, and (2) identify aspects of the program that might need improvement.

Course-embedded assessment plays a major role in the assessment of Student Outcomes. In a sustainable CI process, not all courses are involved in course-embedded assessment. The choice of courses is guided by two criteria: (1) each Student Outcome is assessed with student work in a benchmark course, and (2) required courses are selected as benchmark courses.

Assessment of a benchmark course is conducted with the following in mind: (1) assessment of student work measures the extent to which SOs are being attained, (2) it is not necessary to use all of the student work to assess an outcome, and (3) outcomes assessment is based upon student work and is guided by the grading of that work.

As an example of course-embedded assessment in a sustainable continuous improvement process, EGR 360-Analysis of Engineering Data was selected a benchmark course for assessing the EAC's Student Outcome b. The process and the results of the assessment and evaluation are presented in this paper.

Based on our experience, we conclude that annual documentation of assessment and evaluation of Student Outcomes simplifies preparation of the Self-Study report.

Bibliography

1. Engineering Criteria 2000, ABET, Baltimore, Maryland, 1996.
2. G. M. Rogers and J. K. Sando, "Stepping Ahead: An Assessment Development Guide," Rose-Hulman Institute of Technology, Terre-Haute, Indiana, 1996.
3. 2001 ABET International Yearbook, ABET, Baltimore, Maryland, 2001.
4. American Society for Engineering Education, "How do you measure success: Designing Effective Processes for Assessing Engineering Education", ASEE Professional Books, (1998) pp 5-12.
5. J. W. Prados, G. D. Peterson, and L. R. Latuca, "Quality Assurance of Engineering Education Through Accreditation: The Impact of Engineering Criteria 2000 and its Global Influence," Journal of Engineering Education, 2005, pp 165-180.
6. "Criteria for Accrediting Engineering Programs," Engineering Accreditation Commission of ABET, ABET, Baltimore, Maryland, October 16, 2015.
7. P. Mack, "Using multiple Assessment Methods to Explore Student Learning and Development Inside and Outside of the Classroom," Director of Assessment, American Association of Higher Education, January 15, 2002.
8. Z. A. Yamayee and R. J. Albright, "Direct and Indirect Assessment Methods: Key Ingredients for Continuous Quality Improvement and ABET Accreditation," International Journal of Engineering Education, Volume 24, Number 5, 2008, pp 877-883.
9. Z. A. Yamayee, "The Most Debated Sections of an ABET Self-Study Report: Objectives, Outcomes, and Improvements," Best Assessment Processes Symposium XI, Indianapolis, Indiana, April 3-4, 2009.