AC 2007-2257: A TECHNIQUE FOR PROGRAM-WIDE DIRECT ASSESSMENT OF STUDENT PERFORMANCE

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A Technique for Program-Wide Direct Assessment of Student Performance

Abstract

This paper builds on previous work related to the direct assessment of student performance. Previous work assessed CE program outcomes using a single senior-level capstone design course. This paper illustrates a systematic approach across the entire CE program for the direct assessment of program outcomes. The civil engineering program outcomes reflect the current ABET 3a-k as well as the ASCE Body of Knowledge (BOK).

The approach integrates existing grading practices and correlates the results with the desired program outcomes. This system of direct assessment provides a quantitative assessment without increasing faculty work load, by leveraging what is already being done in the evaluation and grading of student work. This technique uses embedded indicators, which are specific student performance events common to all students in the course such as homework problems, projects and tests. The program director and course directors identify potential embedded indicators that correlate strongly with the desired program outcomes. In addition to the embedded indicators, non-standard measures of program outcomes such as membership in the ASCE student chapter and performance on the Fundamentals of Engineering Exam are considered.

The greatest benefit of using a well developed system of embedded indicators is to provide a quantitative assessment without increasing faculty workload. The quantitative assessment can then be used to validate an "anecdotal" assessment or identify areas for improvement that may not be readily apparent. This simple yet thorough assessment enables programs to spend time developing improvements or identifying needed resource re-allocation instead of collecting and compiling assessment data.

Introduction

The purpose of this paper is to discuss a program-wide assessment system developed at the United States Military Academy (USMA) and used in the Civil Engineering (CE) program. The ABET requirement to demonstrate a process for program assessment is best approached on a continual basis with annual updates. Within the Department of Civil & Mechanical Engineering at the USMA, course assessments are conducted at the conclusion of each course; in attendance are those instructors involved with teaching the course as well as leadership from the department responsible for overall course and program oversight. During the course assessment meeting, an in-depth analysis of the course is conducted which includes not only administrative items, but a review of the course's embedded indicators that contribute to the overall program assessment. The embedded indicators from the course are specifically identified by the program director to provide a direct assessment of student learning for a given program outcome. At the program level, the data from each embedded indicator is compiled into an overall spreadsheet broken down by the 16 program outcomes. The process of identifying specific embedded indicators for each course began during Academic Year (AY) 05-06; the results are now being collected. The focus of this paper is to provide an overview of the assessment process and to provide initial

results of data collected from the fall semester of AY 06-07; additional data will be added to the overall matrix during future semesters to complete the overall program assessment.

The USMA Civil Engineering Program

The USMA CE Program is an ABET accredited undergraduate-only program. The CE Program Outcomes shown in Table 1 are configured to meet the requirements of ABET 3a-k and specify what civil engineering majors should be able to accomplish at the time of graduation from the USMA. With the evolution of the Body of Knowledge (BOK) and the promise of implementation in the near future, the CE Program Outcomes include the requirement to address aspects of construction and asset management (14), business and public policy (15), and leadership (16), the requirements extending beyond previous ABET 3a-k requirements. The CE program is assessed by measuring the extent to which graduates can accomplish the 16 CE program outcomes listed in Table 1.

Table 1 – USMA Civil Engineering Program Outcomes

1. Design civil engineering components and systems.
2. Demonstrate creativity, in the context of engineering problem-solving.
3. Solve problems in the structural, construction management, hydraulic, and geotechnical discipline areas of civil engineering.
4. Solve problems in math through differential equations, calculus-based physics, and general chemistry.
5. Design and conduct experiments, and analyze and interpret data.
6. Function effectively on multidisciplinary teams.
7. Describe the roles and responsibilities of civil engineers and analyze the issues they face in professional practice.
8. Use modern engineering tools to solve problems.
9. Write effectively.
10. Speak effectively.
11. Incorporate knowledge of contemporary issues into the solution of engineering problems.
12. Draw upon a broad education to anticipate the impact of engineering solutions in a global and societal context.
13. Are prepared and motivated to pursue continued intellectual and professional growth—both as Army officers and engineers.
14. Explain the basic concepts of management.
15. Explain the basic concepts of business and public policy.
16. Are leaders of character.

ABET

ABET Criterion 3 clearly specifies the requirement to have in place an "assessment process with documented results to measure outcomes."[1] A common misconception is that if a student earns a passing grade in a course that he/she has met all program outcomes. In reality, this requirement is very difficult to ensure. The beauty of the procedure discussed in this paper is that it provides the framework for such a process—it is still not easy to ensure, but is possible with some additional effort.

The Course Assessment Process

The course assessment process in the USMA CE Division requires each course director to present an annual course assessment, normally at the end of the semester after the course is offered. Most courses are offered during only one semester—for those courses offered more than once in the year, the assessment is accomplished following the semester during which the course is taught predominantly to CE majors.

The course assessment document is prepared in advance of the meeting and distributed to members of the CE division involved with management of the overall program and other related courses. This allows time to develop questions and reflect on the course in advance of the meeting. An outline of the course assessment document is listed in Table 2.

Table 2 – Annual Course Assessment Document Outline

I. Course Administration
A. Catalogue Description
B. Course Objectives
C. Textbook Information
II. Course Content
A. Current Outline of Lessons and Labs
B. Proposed Changes to Lessons and Labs
C. Graded Requirements
III. Course Assessment
A. Course Director Assessment of Course Objectives
B. Program Outcomes Directly Supported by the Course
C. Assessment of Embedded Indicators
D. Assessment of Changes Made this Semester
E. Assessment of Resources and Impacts
F. Historical Course Qualitative Point Average Graph
G. Historical Final Exam Grades Graph
H. Course Time Study Graph
I. Course-end Student Feedback
IV. Program Director's Current Areas of Interest

Sections I and II provide details about the course's content and structure. During the course assessment, previous and proposed changes are discussed and approved or tabled for further discussion at a later time.

Section III.B provides a listing of specific embedded indicators for the given course. Previous work at the USMA has shown how embedded indicators can be used at the course level to assess accomplishment of specific program outcomes.[2, 3,4] Table 3 provides a consolidated listing of the embedded indicators applying to Program Outcome 2, *demonstrate creativity, in the context of*

engineering problem-solving. The authors believe that the identification of between 3 and 6 embedded indicators per program outcome provides an acceptable assessment of outcome accomplishment. Embedded indicators are chosen because they directly assess a given outcome. Theoretically one embedded indicator would be sufficient. Using a minimum of three embedded indicators reduces the impact of an anomalous assessment on the overall outcome assessment. Using more embedded indicators should lead to increased accuracy. However, the authors have found that identifying six true embedded indicators to be a practical upper limit for most of the program outcomes. The embedded indicator can be a specific homework assignment, exam question, portion of an engineering design problem (EDP), or any specific graded event. Unlike an overall course grade that merges a student's performance over the entire course into one final score, the grade on a specific event contributing principally to one outcome is thought to provide a sound assessment. In the case of group work, the resulting assessment would not be student specific, but would still provide an assessment down to the level of a group of several students. Each course in the CE program does not have an embedded indicator for each program outcome.

Table 3 – Embedded Indicators to Assess CE Program Outcome 2

CE390 – As part of the EDP students develop a preliminary site design to include consideration of utility access, traffic assessment and parking, building location, and runoff issues.
CE460 – Students participate in the K'nexercise, a construction management exercise requiring them to serve as contractors, construction managers, architect-engineer firms, and suppliers.
CE489 – Judging of student project posters prepared for display on USMA Projects Day.
CE489 – Judging of student project presentations on USMA Projects Day.
CE492 – Overall result of embedded indicator matrix. NOTE: CE492 is the CE Capstone Design Course. An extensive embedded indicator system encompasses the entire course.[5]

Section III.C of the document presents the results of the overall program outcome assessment. The implementation of this process began during AY 05-06 with the first results based on embedded indicators being collected during AY 06-07. Throughout the semester, each course director collects assessment data in the form of student grades on events associated with the embedded indicators and consolidates the data in Table 4. The data for each embedded indicator lists the average grade earned, and high and low scores. The course director also tracks the number of students that earn failing grades on the indicator. This process is repeated for each course with a similar table created for each. Data to fill the table comes directly from the automated grade collection system (USMA Grades) used by all course directors and instructors. In the case where an embedded indicator consists only of a portion of a graded event, the event can be broken into two events with the appropriate event grade data being recorded in Table 4.

Table 4 – Consolidated Listing of Embedded Indicator Assessment Results

Program Outcome	Total Points Possible	Average Percent Earned	High Percent Earned	Low Percent Earned	Total Number of Failures	Number of CE Majors
3c	20	85	97	61	1	40
8	40	81	89	68	0	40
11	35	91	99	81	0	40
12	75	85	96	60	3	40

The Program Assessment Process

After collecting data from all courses taken by all CE majors, the program director consolidates the results into Table 5. The course results are collected according to student class graduating year for the purpose of assessing the degree of program outcome accomplishment for each class. Data could be consolidated by academic year; however, the resulting data is more useful when collected by graduating class. Typically, students at the USMA are enrolled in CE courses according to their graduating class, thus data collection by class is possible. For each program outcome, the total point value of the assessed indicator is determined along with a weighted average for the outcome. Since students can earn a total of 2000 points in all CE courses at the USMA, a consistent weighted average is possible.

Table 5 – Consolidated Embedded Indicator Results at the Program Level

Program Outcome	Total Point Value of Assessed Indicators	Overall Weighted Average	Total Number of Student Failures	Total Students x Courses Taken	Percentage of Student Failures
1	1600	86%	9	160	6%
2	1200	81%	5	200	3%
3a	600	87%	3	40	8%
3b	600	90%	1	40	3%
3c	600	82%	2	40	5%
3d	600	83%	2	40	5%
4	0				
5	500	78%	10	240	4%
6	700	80%	2	120	2%
7	500	88%	0	240	0%
8	1200	90%	5	280	2%
9	800	82%	7	240	3%
10	800	90%	2	160	1%
11	600	80%	0	280	0%
12	450	91%	0	200	0%
13	300	85%	0	160	0%
14	1000	92%	1	40	3%
15	300	82%	1	40	3%
16	300	95%	0	40	0%
Average (AVG)	703	85.7%			
Standard Deviation (SD)	351	4.9%			
AVG + 1SD	1054	90.6%			
AVG - 1SD	352	80.7%			

From Table 5, the program director can quickly determine several important aspects about the program that allow him/her to make needed adjustments.

Total Point Value of Assessed Indicators. The "Total Point Value of Assessed Indicators" column allows the program director to determine which outcomes are being adequately assessed from within course work by comparing the particular outcome average with the "Average (AVG) of Total Point Values" and "Standard Deviation (SD) of Total Point Values." In cases where the resulting outcome point value is one or more SDs below the AVG, the program director can choose to assess activities from outside course work, add additional embedded indicators for the outcome from within coursework, or, if neither is possible, add content to the program to address the shortcoming. An example of an outcome having a point values one SD below the average are outcomes 13 (Continued intellectual and professional growth), 15 (Concepts of business and public policy) and 16 (Are leaders of character). In the case of Outcome 13, there are not adequate opportunities within course work to adequately assess the outcome. Another place to seek assessment data would be the FE Exam study session attendance and exam pass rate, and enrollment in the ASCE Student Chapter. In the case of Outcome 15, this was a new addition based on the onset of the new BOK. Additional coverage is necessary in the CE curriculum in order to allow more reliable assessment of this outcome. In the case of Outcome 16, students at the USMA receive extensive education on leadership and ethics outside of the academic curriculum that must be captured and assessed separately then incorporated into the overall assessment. Also, the USMA's automated grading system provides an option to use indicators found in non-engineering courses such as Military Leadership to provide additional coverage for Outcome 16.

Overall Weighted Average. The "Overall Weighted Average" column is the most important part of the table and provides a direct assessment of student performance by program outcome. Based on the resulting percentage, the program director can determine outcomes in which students are performing well, those that might require additional emphasis, and those that perhaps require assessment from other areas of the program. In some cases, it may not be possible to adequately assess a program outcome from within course work. It may be necessary to collect assessment data from other activities to determine a meaningful assessment of the program outcome. An example of an outcome requiring attention is Outcome 5 (Design and conduct experiments) because the resulting overall weighted average is more than one SD below the average. If there were resource constraints in the program, the program director could also choose to redirect effort from outcomes performing well above the average. An example of this situation is Outcome 12 (Impact of engineering solutions) and Outcome 16 (Leader of character).

Total Number of Failures**. S**tudent failures are tracked at the program level. In the case where a particular student name appears multiple times, the program director and course directors reserve the right to administer an additional validation exercise to ensure the student is able to meet the requirements of the outcome(s) he/she failed as part of regular assignments. The Senior Design Project (CE492) and the Senior Seminar (CE400) provide a means to validate successful completion of the requirements. Students identified as failing to meet specific program requirements are mentored by faculty members through successful completion of the requirements. Graded events within CE492 and CE400 are selected that adequately evaluate a given requirement. For example if a student has failed to meet Outcome 9 (Write effectively), he/she may be mentored and evaluated on the engineering report in CE492 and/or the Mead Essay in CE400. If this system is to be employed, it is important that students are aware of and understand the requirement to accomplish specific tasks in the program in addition to earning an

overall passing grade. Also, the validation courses must provide adequate coverage of all 16 Outcomes.

Total Students x Courses Taken. This column provides the program director the total number of CE majors multiplied by the number of courses taken. This is necessary to provide a basis of calculation for the percentage of student failures by program outcome.

Percentage of Student Failures**.** This column provides the program director a percentage of student failures and is useful for comparison between outcomes. The value proves useful when examining outcomes possibly needing additional emphasis and is very useful in examining the accomplishment of ABET Criterion 3. In the case of Outcome 1 (Design CE Components and Systems) and Outcome 3a (Solve problems in structural engineering), a relatively higher percentage of student failures provides the program director additional warning that emphasis may be required in courses contributing to the outcome.

Conclusions

This procedure of assessing accomplishment of the CE program outcomes using embedded indicators has demonstrated several direct and indirect advantages. First, it provides an objective, direct assessment of student performance in each of the program outcomes. Objectivity is difficult to achieve; using this system removes much of the subjectivity that can result when several different assessors are involved in the process.[6] The system also provides a mechanism for identifying students not meeting program outcomes and for addressing ways to correct for their shortcomings. Second, this procedure requires little additional workload for faculty members because it is based largely on student grades, the processing of which is mostly automated. Third, this system provides a metric which enables effective program adjustment decisions to be made. Finally, using a common course assessment system including embedded indicators across the CE curriculum has an indirect benefit of enriching faculty understanding of how each course contributes to the program and generates ownership of the program outcomes.

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