Setup of a Course Level Assessment For ABET 2000

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Abstract

The ABET 2000 accreditation criteria requires that an institution have in place an assessment program to ensure the quality and continuous improvement of the educational process. There have been many papers published in the last few years on the topic of assessment as it relates to the new criteria. For the most part, the existing literature deals only with program level assessment methods, even though a comprehensive assessment program includes both program and course level assessment. In the present paper a new course level assessment model using formative course grading is presented. The primary focus of the method proposed herein is to strongly align the relationship between the course objectives, the various tasks that a student performs during a course, and the methods that are used to assess those tasks. This paper describes the establishment and use of this approach on a trial basis for a single course.

I. Introduction

The ABET 2000 accreditation criteria require that an institution have in place a comprehensive outcomes assessment program to ensure the quality and continuous improvement of the educational process[1]. There are two general levels of assessment[2]:

- Course Level Assessment
- Program Level Assessment

Course level assessment attempts to ensure that in a particular course the required material is sufficiently well taught and understood. Program level assessment addresses the program outcome indicators as well as assessing the content, sequence, and integration of all courses within a program. Ressler and Lenox[3] provide a program assessment model with integrated course level assessment that is being used at their institution. They correctly assert that these two levels of assessment are clearly not independent, and that "in a well integrated curriculum, course assessment can never take place in isolation." For instance, the inability of students to meet a particular course objective may be due to difficulties with a previous course. Thus, in an integrated

assessment plan course level assessments should feed into the overall program assessment.

The faculty and administration of the engineering programs at Saginaw Valley State University (SVSU) have developed a Manual of Assessment[4] as the initial step in implementing a suitable departmental assessment program. This manual lists six Mechanical Engineering Program Objectives that are linked to and measured by twelve Program Outcomes. Six different methods to assess these twelve outcomes are described in the manual and are listed in Table 1 below. These six methods are representative of approaches to program assessment that are being used at a number of surveyed institutions[5].

Outcome assessment tools may be loosely classified as either pre-graduation or post-graduation indicators, depending upon when they are administered[6]. One possible shortcoming of the assessment program described in the SVSU Manual of Assessment (as well as at the surveyed institutions) is that most of the tools used to measure the outcomes of the program take place either at the end of the senior year or post graduation. Therefore it seems prudent to investigate the increased use of pre-graduation assessment tools as input to program level assessment.

Table 1.
Assessment Methods Used at SVSU

• Senior Design Jury Panels
• Student Alumni Surveys
• Employer Surveys
• Capstone Design Report Review
• Graduate Placement Data
• Annual Student Meeting/Survey

II. Pre-Graduation Assessment Tools

Pre-graduation indicators can include transcript data (courses attempted by students and corresponding grades)[6], student portfolios (multiple courses), and course portfolios (individual courses). Course portfolios are currently being used at several institutions. The theory behind the use of portfolios is that by accumulating a student's work over time one can demonstrate whether or not a student is progressing towards and achieving educational goals[7]. However, at least one school that began using portfolios has discontinued the practice[8]. This was due to the large effort involved in maintaining the portfolios as well as the difficulty of obtaining quantifiable data. Clearly, available resources and utility of obtained data must be considered when designing any assessment program.

The concept of using course grades as an assessment tool is attractive since this information is already being collected so in theory there is no undue burden added to faculty by the assessment process. For example, Conner and Goldman[9] report the use of a weighted average of student course grades linked to program objectives as a program

assessment tool. Georgia Institute of Technology[10] also uses assignment of grades by professors as one of their outcomes assessment tools. If a student is assessed in the context of a course, the instructor has a large number of graded assignments including tests, homework, and projects upon which to base the summative assessment. Thus each instrument does not have to stand the same rigorous tests of validity and reliability as would instruments in a single measure environment[11].

These assessments are based on a linkage between the program level and the course level that is usually established through the coupling of the course objectives to various program outcomes. Tacitly implied is the assumption that a student has achieved the course objectives simply by completing a course with a passing grade. However, summative course grades provide little insight regarding if all or even most of the course objectives have been met, and thus limit their usefulness for providing feedback to individual students or to the program as a whole.

The assumption that a student has met the stated objectives of a course by successfully completing that course must be questioned. It seems reasonable to suppose that some students who earn a C in a course may not have mastered all of the course objectives. In fact, there is really no guarantee that an A student has met all of the course objectives. Shaeiwitz[12] astutely states "with partial credit, it is possible for a weak student to go through an entire engineering curriculum and receive a degree without having solved one problem correctly on a test." Clearly, while the use of final course grades as input to program assessment is inviting, further investigation of what comprises the final grade is needed.

There are at least two reasons that there may be no concrete link between course grades and course objectives. First, after faculty set up (or are handed) objectives for a particular course, they may not refer back to them while conducting the course, resulting in assignments and tests which may have little to do with the stated course objectives. Secondly, even if the instructor does teach with a view to the course objectives, it is not unreasonable to find students who fail to master one or more of the stated objectives of a course yet still manage to pass the course. Further, it is conceivable that even in a class with a Gaussian grade distribution centered on C to have a majority of students fail to demonstrate mastery of one of the course objectives. These possibilities beg the questions: How many course objectives must a student master to be sucessful? How do we know if individual course objectives are consistently being met?

Addington and Johnson[13] describe an approach that uses grades on individual assignments to measure program outcomes. They link particular homework assignments directly to program outcomes and record the mean and standard deviation of the all students' grades. This method has the benefit of not looking only at summative course assessment data. However, by averaging class performance, information regarding the actual number or percent of students meeting an outcome is lost. For example it would be important to know that seventy percent of the students mastered an assignment, while the statistic that the class average for the assignment was seventy percent is less informative.

In the next section a new course level assessment model is presented that attempts to address the questions and concerns described above. The primary focus of the method proposed herein is to strongly align the relationship between the course objectives, the various tasks that a student performs during a course and the methods that are used to assess those tasks. Specifically, for each performance criteria associated with a particular course objective, distinct assessment measurements are identified. A quantitative evaluation of these assessment measurements provides statistical data that can be used in a variety of ways for course and programmatic modification.

III. Developing a Course Level Assessment

The eight-step model that Rogers and Sando[14] created as an assessment plan development guide was used in framing the new course level assessment model at SVSU. Each step was reviewed to find what current practice was already in use and to identify gaps to be filled by the new course level plan. The purpose of the proposed assessment program is twofold:

- To ensure that a student who successfully completes a course has in fact demonstrated proficiency in a majority of the course objectives.

- To provide a feedback mechanism through which student performance in individual courses is transmitted to other faculty for use in the continuous improvement loop.

Rogers and Sando[14] describe the following eight steps for developing an assessment plan:

1. Identify goals
2. Identify objective(s)
3. Develop performance criterion(a)
4. Determine practice(s)
5. Specify Assessment Methods
6. Conduct Assessments
7. Determine feedback channels
8. Evaluate

The Saginaw Valley State University Manual of Assessment defines the department's six program objectives and ties them in with twelve program outcomes. The twelve program outcomes are in turn referenced by individual courses. The new course level model is structured to assure that students with passing grades have in fact met the course's objectives that are in turn tied to program outcomes. Also, the feedback loop provides a needed link between the courses and the overall program. Thus, the proposed assessment program will provide a much closer link between the program objectives, the course objectives, and the learning outcomes that faculty actually measure (e.g. tests, homework, etc.). The following model assessment plan provides the linkages and the tools that provide measurements to determine if students have met program objectives.

IV. Setup of Course Assessment for ME 315: Engineering Measurements

A typical course is used to illustrate the setup and execution of the proposed course level assessment. Some, but not all, of these steps are currently done by faculty, however, they have not been integrated into a true course assessment. The eight-step guide of Rogers and Sando is used to develop an assessment method that is being implemented for the first time at SVSU for the test course of ME 315, Engineering Measurements, in the Fall 1999 semester.

1. Identify goals.

The goals of a course should resonate with those of the program in which it resides. Further, the totality of the courses in a program should be interwoven in such a way to ensure that there is adequate and uniform coverage of topics related to all program objectives. Therefore, the goals of an individual course must directly address the program outcomes to which the course is expected to contribute. However, the course goals should not simply be a restatement of the program outcomes. Rather, they should be tailored to fit specific courses.

Four out of twelve program outcomes are cross-referenced to our example course, ME 315 Engineering Measurements, in the SVSU Manual of Assessment[4]. They are as follows:

1. An ability to apply knowledge of mathematics, science, and engineering.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.
5. An ability to identify, formulate, and solve engineering problems.
7. An ability to communicate effectively.

The four program outcomes listed above are used to create the distinct goals of ME 315, which are given in Table 2 below.

Table 2: Goals for ME 315 Engineering Measurements

Students who successfully complete ME 315 will have:
1. An ability to apply knowledge of Calculus and Physics to understanding measurement system design and performance.
2. An ability to design experiments, including performing uncertainty analyses and to analyze and interpret data using statistical methods.
3. An ability to identify, formulate, and solve engineering problems involving measurement system selection, calibration, and performance.
4. An ability to effectively communicate engineering solutions using a structured problem solving format and with clear, effective graphs created with modern software.

2. Identify Objectives for Each Goal

A set of course objectives relating to the stated goals is developed next. It is important to note that these course objectives cannot encompass all that an instructor plans to teach or that students are expected to learn in a given course[2]. They should represent the concepts and materials that are central to the course, rather than peripheral content. An example of a typical set of course objectives is given in Table 3.

Table 3: Course Objectives for ME 315 Engineering Measurements

Course Objectives:
1. To provide a fundamental background in the theory of measurements and measurement system performance.
2. To convey the principles and practice for the design of measurement systems and measurement test plans, including the role of statistics and uncertainty analyses in design.
3. To establish the physical principles and practical measurement techniques most important to engineering applications.
4. To teach the graphical presentation of results, including the use of modern software.

3. Develop Performance Criteria for Each Objective

A set of performance criteria for each objective is now developed. The performance criteria are specific, measurable items that are confirmable through evidence[14]. The development of performance criteria is a difficult task, and requires significant effort on the part of faculty. One benefit of this step, however, is that it forces faculty to think deeply about what a particular course should accomplish. Table 4 lists the performance criteria for one of the course objectives for our example course.

4. Determine Practices

These are the methods by which the students acquire skills. These practices may take the in the form of homework, reports, oral presentations, projects, or tests. Faculty typically list the practices in the course syllabus. For ME 315, the practices used include homework problems, hour exams, and a final exam.

Table 4: Sample performance Criteria for ME 315 Objective #1

Objective # 1: To provide a fundamental background in the theory of measurements and measurement system performance. **Performance Criteria:** 1.1 Students will demonstrate an understanding of measurement standards in relation to calibration. 1.2 Students will demonstrate an understanding of accuracy, sensitivity, and error in the context of measured vs. predicted response. 1.3 Students will demonstrate an understanding of static and dynamic characteristics of signals including the ability to recognize and predict the behavior of first and second order measurement systems.

5. Specify Assessment Methods to be used for Each Objective

Each of the performance criteria will be assessed either by the practice opportunities identified above (homework, written reports, oral presentations, projects or tests), or by other methods. This step identifies specific assessment methods for each objective; multiple measures of a criterion are best. For instance, Performance Criterion 1.3 above is assessed in homework assignments #4 and #5 and hour exam #2—problem #3. The key is that each homework set, exam question, etc., have an evaluation purpose to determine if a student has a specific skill or can perform a specific task.

Each homework set and test question is evaluated to determine areas of competency or weakness. Final exam questions are then chosen based on areas where the majority of students have not demonstrated competence, thus giving students another opportunity to demonstrate mastery of program objectives. There is little to be gained by putting questions on a final exam that students have already demonstrated ability and mastery. Testing for testing's sake does not advance student learning.

6. Conduct assessment

The SVSU course model uses on-going formative assessment. Formative assessment is designed to provide information for the purpose of improving the course. It does this by providing continual feedback of academic performance to individual students. With this assessment method, course assessment is being done continuously during the course. In essence, the assessment consists of the following:

1. Keeping track of students' grades on tests, homework, reports, oral presentations, projects, etc. Scores for individual test problems, not just total test scores, are recorded to provide the most useful feedback and assessment. A spreadsheet works best to record this information. Recall that these subset scores have been linked to performance criteria. Homework sets that encompass multiple performance criteria

must also be broken down and recorded separately. Assignment of problem sets to assess particular performance criteria avoids this bookkeeping problem and allows students an opportunity to focus on specific learning objectives.

2. Running scores on particular performance criteria during the course gives the feedback needed to guide midcourse changes—which is the essence of formative assessment.

The scores for all tasks evaluated are tabulated at the conclusion of the course. A seventy percent (70%) average is selected as the minimum competency level that a student must attain in order to pass a performance criteria. For instance, suppose performance criteria P1.1 is measured by homework assignments 1 and 2, hour exam #1—problem 1, and final exam—problem 2. These four measures would be averaged to determine if a seventy percent average has been achieved and the performance criterion passed.

The determination as to whether a student has mastered the course objectives can be made after calculations have been done for all performance criteria. When seventy percent (70%) of the performance criteria are passed an objective is assumed to be mastered. However, to determine if an objective has been mastered using discrete numbers of performance criteria, passing two out of three (67%) or three out of four (75%) performance criteria for an objective is deemed acceptable, as summarized in Table 5.

Table 5
Mastery of a Course Objective Based on Number of Performance Criteria Passed

Objective with 3 Performance Criteria	**Objective with 4 Performance Criteria**	
Number of Performance Criteria Passed at 70% Level	Number of Performance Criteria Passed at 70% Level	**Objective Met?**
3 of 3	4 of 4	yes
2 of 3	3 of 4	yes
1 of 3	2 of 4	no
0 of 3	1 of 4	no
	0 of 4	no

Finally, the course grade for all students can be determined. The student must meet a majority of the objectives of the course to achieve the minimum requirement for a letter grade C in a course. The following relationships between course objectives and grade ranges are proposed. The exact grades (A, A-, B+, etc.) are determined by numerical average. Therefore, it may be possible, although unlikely, that a student meeting for example only two of three course objectives could have a higher numerical average than a student meeting three of three objectives. Testing of the model in practice will determine if this is in fact a difficulty.

Table 6
Student Course Grade Based on Mastery of Course Objectives

Course with 3 Objectives	**Course with 4 Objectives**	
Number of Objectives Met	Number of Objectives Met	**Grade Range**
3 of 3	4 of 4	A through B
2 of 3	3 of 4	B- through C
1 of 3	2 of 4	D
0 of 3	1 of 4	F
	0 of 4	F

7. Determine feedback channels

There are multiple feedback channels that direct information regarding student performance in a course to faculty teaching other related courses (including other departments), the department administration, and the students. Feedback can be thought of in a ladder format with the rungs being represented by the upstream faculty (those teaching prerequisite courses), the current course faculty, and the downstream faculty (those teaching follow up courses), all of whom have different concerns:

- Upstream faculty – What is the positive and negative feedback on student skills?
- Current course teacher – Which topics need more or different treatment?
- Downstream faculty – What topics need more / less coverage than usual?

A formal method of exchange is needed, rather than the anecdotal evidence that is sometimes used. At SVSU, an annual meeting is used for this purpose. If a particular objective is not met by a large number of students, faculty should try to determine if this could be remedied via internal or external changes to the course or in preparatory courses. Prerequisite courses could be investigated if external changes are needed. If the prerequisite course is from another department (e.g. math) a meeting should be set up to discuss possible solutions. Further, subsequent course instructors could be alerted that students might be weak in an area of the particular objective.

8. Evaluate

Evaluation is accomplished by computing statistics regarding student achievement in each objective and performance criterion. The test course (ME 315) for this model is still in progress at the time of this writing, however the following table provides a hypothetical example of these statistics for a course with three objectives, each having three performance criteria.

Table 8
Sample of How the SVSU Course Level Model is Used

Student	Performance Criteria 1.1	Performance Criteria 1.2	Performance Criteria 1.3	Objective #1 Met?	Performance Criteria 2.1	Performance Criteria 2.2	Performance Criteria 2.3	Objective #2 Met?	Performance Criteria 3.1	Performance Criteria 3.2	Performance Criteria 3.3	Objective #3 Met?	Total Course Objectives Met	Course Grade Range
1	x	x	x	yes	x		x	yes	x	x	x	yes	3 of 3	A ↔ B
2	x	x		yes	x			no	x	x	x	yes	2 of 3	B ↔ C
3	x	x	x	yes	x	x	x	yes	x		x	yes	3 of 3	A ↔ B
4		x	x	yes		x	x	yes	x		x	yes	3 of 3	A ↔ B
5	x	x	x	yes	x		x	yes	x	x	x	yes	3 of 3	A ↔ B
6			x	no			x	no		x	x	yes	1 of 3	D
7	x	x		yes	x			no	x	x		yes	2 of 3	B ↔ C
8	x			no		x		no	x			no	0 of 3	F
9	x	x		yes	x			no	x	x		yes	2 of 3	B ↔ C
10		x	x	yes	x	x	x	yes		x	x	yes	3 of 3	A ↔ B
Total %	70%	80%	60%	80%	70%	40%	60%	50%	80%	70%	70%	90%	80%	

x $\Rightarrow$ indicates that a performance criterion has been met at the 70% level

The information contained in this table can be used in a variety of ways. In the above example, 80% of the students passed the course. However, only 50% mastered course objective #2. In particular, they seemed to have trouble with performance criteria 2.2(40% passing) and 2.3(60% passing). Weaknesses in meeting the performance criteria could be due to problems in a prerequisite course or lack of adequate understanding in the current course. Feedback, both to the upstream and downstream faculty, should occur. Re-evaluation of current course teaching techniques should also be analyzed.

V. Conclusions

A course level model assessment program has been described. While this program would take some effort to setup and maintain, the effort is not large and the benefit of obtaining quantifiable evidence that our students are meeting program objectives make it worthwhile. This assessment tool is being implemented on a trial basis in a single course at SVSU, and if successful could be expanded to the entire curriculum.

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