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Thomas Currin, Southern Polytechnic State University

A Model for Successfully Measuring Program Outcomes

Abstract:

Since the substantive changes in accreditation criteria in 2000, the proliferation of outcomes assessment requirements throughout all levels of education has led many engineering technology departments to re-examine what they are trying to do, why they are doing it, and how they know they have accomplished what they set out to do. Accomplishments must be measured against some benchmark and ideally fed back into the planning process to improve the curriculum and its content. Therein lies the dilemma. How can one produce a tangible measure of effectiveness when intangibles are being assessed? How can both the technical and liberal education components of the program be assessed?

This paper addresses how one department set out to solve just such a dilemma. Using a capstone senior project course with, among others, tangible learning outcomes directed to providing a vehicle for outcomes assessment combined with periodic reporting techniques directed to the faculty responsible for specific courses, the department has refined its assessment model. The capstone senior project course has demonstrated that immediate improvement to the curriculum including revision of learning outcomes of ongoing courses is possible and likely probable. Since outcomes assessment is revisited each semester, the course has provided the needed linkage to the university's assessment model and allowed the department to respond to the dynamics of the student body through the identification of developing weaknesses. For example, students historically have been quite good at project management and visualization of the construction techniques used to bring a project to fruition. The implementation of the outcomes assessment model detailed herein has identified weaknesses in these areas in the current student body. As a result changes have been incorporated into several courses to address this situation. This paper maps the successful process which led to the changes so that others may utilize the model at their institutions.

Tangible Measures of the Intangible:

Whenever faced with the task of measuring/assessing and evaluating program outcomes, the challenge lies in developing the tangible measurements which can be used to evaluate intangible outcomes. For example, ABET's Technology Accreditation Commission (TAC) specifies in Criterion 2, Program Outcomes, "An engineering technology program must demonstrate that graduates have: … i. an ability to understand professional, ethical, and social responsibilities, …". While most would agree that an ability to understand social responsibilities should be a program outcome, simply defining the term social responsibility can be daunting. Add to that the creation of an assessment tool, measures of effectiveness, and an evaluation methodology which identifies where and how well this ability is being attained by the student and the task can appear insurmountable. Such was the case at our school when we set out to define a model for measuring program outcomes.

The key to our successful assessment model development program was, in part, a thorough understanding of the definitions associated with the various components of the

continuous improvement planning process. Rather than define a set of institution specific terminology, we chose to adopt the following four definitions, all of which are being used by the all of the commissions of ABET.

> Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.
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> 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 skills, knowledge, and behaviors that students acquire in their matriculation through the program
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> Assessment is one or more processes that identify, collect, and prepare data to evaluate the achievement of program outcomes and program educational objectives.
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> Evaluation is one or more processes for interpreting the data and evidence accumulated through assessment. 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.

Given these definitions then it was obvious that a model for successfully measuring program outcomes must be aware of the data requirements of the evaluation process and how it would use the data. Also, it was obvious that one assessment vehicle would not suffice to assess all of the program outcomes, but rather multiple independent sources of data would be required. Furthermore, the entire continuous improvement process is only as good as the data upon which it is based. Without high-quality data inputs, positive decisions and actions which improved the program would be impossible.

Developing an Assessment Vehicle:

Identifying the vehicles by which data could be collected and prepared for input to the evaluation stage of the continuous improvement process resulted in many options. Some assessment vehicles thought to be useable were: exams such as proficiency exams; individual and/or team projects; faculty evaluations of individual courses; advisory board input; student interviews; and graduate surveys. While each had their advocates there was no single or combination of assessment vehicles which the faculty agreed could be the primary assessment tool. What was needed was a primary assessment vehicle which successfully measured effectiveness, produced useable data while being easy to implement, and which produced results which were easy to document and communicate.

Many attempts to implement continuous improvement plans fail because faculty and staff see the assessment phase as being far more labor intensive than reward-bearing. We did not wish to increase the load on the faculty by adding tasks which did not yield immediately useable results nor did we want to exclude processes which we were already doing which with adaptation could serve as an effective assessment tool. This led us to investigate the program's existing capstone project course for its potential to serve our assessment needs.

Using the Capstone Course for Assessment:

The senior capstone course was originally developed as an evaluation tool. Its intent was to provide feedback back to the faculty as to the ability of the students to synthesize material learned in other courses by pressing the limits of their problem solving skills. Originally developed and implemented years before ABET accreditation adopted outcomes-based assessment, the course challenged student design teams to solve real-world problems while mimicking a consultant-client relationship. The information feedback consisted mainly of discussions among faculty at department meetings and usually had little or no documented data to support assertions of student weaknesses. However, the potential for this course with modification to serve as a primary assessment vehicle for the program was recognized.

The capstone course is unique in that by its very nature it requires students to demonstrate their abilities in each of the TAC of ABET program outcomes. While it was not appropriate to simply list the TAC of ABET program outcomes as the learning outcomes of the course, it was and is proper to develop learning outcomes for the course which support the assessment and subsequent evaluation of the program outcomes. For example, a learning outcome of the capstone course is, "Upon completion of this course the student will be able to identify the data collection needs of a project." This directly supports TAC Criterion 2, f, Program Outcomes which states, "Each program must demonstrate that graduates have an ability to identify, analyze, and solve technical problems." Similarly, the production of a set of engineering design plans provides insight as to the program's ability to produce graduates that can function effectively on teams, communicate effectively, apply creativity in design, as well as many other program outcomes.

As work progressed into ways to modify the capstone course to meet our assessment needs it became clear that multiple assessment tools could be developed and used within the capstone course framework. Also, since our goal was program assessment and as such groups such as industry and alumni needed to be involved in the assessment and evaluation processes, the course could allow participation by these groups. For example, a survey of potential employers who attended the final project presentations could be crafted to provide valuable input. Similarly, alumni could serve as mentors to student design teams and assess the teams' skills and abilities as they relate to the program outcomes. An obvious group, the students, could conduct peer evaluations of the student design teams both between teams and within teams and identify the program's strengths and weaknesses. In short, the ability of the capstone course format to serve as a vehicle for multiple assessment tools greatly exceeded our expectations.

With the great potential we were realizing came some hesitation. Incorporating the assessment tools within the capstone course could not become intrusive. Likewise, involving outside parties such as industry and alumni in the course could not change the basic nature of the experience. The students were aware that the capstone course was originally developed as a tool to identify strengths and weaknesses of the program and knew that certain activities would be required purely for assessment purposes. However, the preservation of the unique nature of a comprehensive capstone design experience was important to both faculty and students and neither group would allow this to see substantive change.

Assessment Tools Examined:

The following table identifies many of the assessment tools examined for their potential use within a capstone course framework. In each case the tool was examined for its potential to produce useable data easily. For each tool the table identifies the stakeholder/assessors, those who would actually produce the data being collected, as well as the level of effort required to obtain and provide the preliminary reduction of the data for input to the evaluation phase of the continuous improvement process. A subjective evaluation of the usefulness of the data output in the evaluation phase is presented along with an expected level of intrusiveness into the day to day operation of the capstone design course. In each case it was assumed it was the responsibility of the instructor to collect the data and prepare it for use in the evaluation phase. A detailed explanation of each tool follows this table.

Table 1. Potential Assessment Tools

Tool	*Primary Stakeholder (Assessor)*	*Data Collection and Preparation Difficulty*	*Frequency*	*Suitability to Evaluate Program Outcomes*	*Intrusiveness*
Survey of Learning Outcomes by Instructor	Instructor	Low	Twice per semester	Good	Low
Survey of Learning Outcomes by Students	Students	Low	Twice per semester	Good	Low
Survey of Program Outcomes by Instructor	Instructor	Low	Once	Excellent	Low
Survey of Program Outcomes by Students	Students	Low	Once	Excellent	Low
Grading Forms	Instructor	Medium	Twice per semester	Variable	Variable
Alumni/Industry Evaluations	Mentors	High	Variable	Variable	Variable
Faculty Evaluations	Presentation Attendees	High	Once	Fair	Low
Peer Evaluations of Individual Students	Students	Medium to High	Variable	Fair	Variable
Peer Evaluations of Design Groups	Students Instructor	Medium to High	Variable	Fair	Variable

As can be seen from the table we identified three basic types of assessment tools which could make use of the capstone design course format. They are surveys, forms of grading, and a combination. Each type was found to have its strengths and weaknesses as enumerated below.

The first two tools shown in the table are surveys. They rely on the individual taking the survey to provide his/her opinion of how well the learning outcomes are satisfied. The survey of learning outcomes by the instructor requires the instructor to list the learning outcomes for the course then rate each student at mid-semester and at the end of the semester as to how well they have met the course learning outcomes.

Likewise, the survey of learning outcomes by the students has the student rating themselves twice during the semester as to how well they think they have achieved the course learning outcomes. An example of a survey form to be used by students is shown in Figure 1. To make sure the students put forth their best effort when responding to the survey, it is suggested that students write their names on their forms. However, the responses should not be viewed until after course grades have been finalized so as to avoid any implication that this survey is a grading tool.

In either case the instructor must summarize the surveys and identify which outcomes were successfully achieved and which were not. Depending on how detailed a rating system is used, a quality rating showing how well the outcome was achieved can be determined. A comparison can be made between the instructor's assessment and the students' assessment and any disconnects easily identified for further evaluation in the next phase of the improvement process. Regardless of the rating system used the data acquired for each course learning outcome must be correlated to a specific program outcome when input to the evaluation phase.

The need to correlate the course learning outcomes to the program outcomes is eliminated if program outcomes are the data items being surveyed. Whether TAC's a though k program outcomes or, if different from TAC's, the school's program outcomes are surveyed a problem surfaces with how students view a survey of this type. Students are wary of questions which they perceive could lessen their chances to graduate or somehow diminish the value of their achievement. When testing a survey of program outcomes several students asked if the results of the survey would affect their graduation. It was clear to us that when utilizing this instrument, we would need to reassure students that it would not help or harm their academic progress. If they were not so informed the usability of the output would be questionable.

All four of these surveys are easy to administer, provide high quality output and should not be intrusive. They provide input to the continuous improvement process which otherwise would not be available and allow a dispassionate evaluation of the ability of the program to satisfy the program outcomes. Other types of instruments provide less usable information.

Figure 1. Outcomes Survey completed by students

Mid-semester Outcomes Survey

At the beginning of the semester you were given a syllabus that included the "learning outcomes" for the course. Learning outcomes are statements that specify what learners will know or be able to do as a result of a learning activity.

For each of the following statements please specify a number from 1 to 5 which best describes your level of agreement. (See scale) For those you assign 3 or less, please include a sentence describing how the course could be improved such that you would have rated that outcome 4 or higher.

1=Strongly disagree 2=Disagree 3=Not Sure 4=Agree 5=Strongly Agree

1. **I am able to prepare a scope of services for a project.**
2. **I can work together as part of a design team.**
3. **I am able to prepare technical reports.**
4. **I can identify the data collection needs for a project.**
5. **I am able orally present my findings to my peers and faculty.**
6. **I can prepare meaningful progress reports.**
7. **I am able to prepare a set of engineering plans.**
8. **I am able to present and defend a proposal for a project.**
9. **I am able to integrate knowledge from other classes.**
10. **I am able to work independently.**
11. **I am able to prepare a feasibility study**

When looking at the capstone course for assessment use the idea of modifying the existing grading instruments within the course was brought to light. It was found that many schools have attempted to make double use, both grading and assessment, of these instruments. As was found elsewhere, we discovered that this tool could be quite intrusive, since it required the instructor to develop grading methods which were not conducive to achieving the learning outcomes for the course but were directed solely at program assessment. This had the potential to confuse students as to why they were doing a particular activity for a grade when it did not directly support the purposes of the course. For example, a capstone course format does not lend itself to examinations, yet these are the easiest instruments to use as an assessment tool. Incorporating an examination into the course just to provide assessment data does not support a quality learning environment.

The third group of assessment tools is the evaluations which, in essence, are a combination of surveys and grading. The evaluation whether done by faculty, industry, alumni or students is the same as previously defined. That is to say, the process is one of interpreting data and evidence and rendering a decision as to what extent the program outcomes have been satisfied. The results of such an activity are dependent upon the amount and the quality of data used to conduct such an evaluation. Therein rests the problem with each of these survey tools. With most of the evaluators seeing the product of the students' efforts only once or at most twice during the semester prior to their evaluation, they have little upon which to render their decisions. Our experience was that the evaluators were quite frustrated during the process since that had so few data points with which to work.

The four types shown are all more labor intensive than the other tools. Each requires an extensive amount of time by the instructor in the development of a survey, defining for the target group the evaluation process they are to follow, and the testing of its usability. In addition, the summary and interpretation of the data so that it's in a format that can be easily used in the evaluation process can be time consuming. Ensuring that the summaries are bias free can be difficult at times as well.

Figures 2 and 3 are examples of evaluation forms used by various stakeholders. The form shown as Figure 2 can be and has been used by industry, alumni, and faculty in attendance at the final capstone project presentations. Figure 3 has been used by students to evaluate their peers at mid-semester. These forms have been used to serve double duty in that the data generated has been used to evaluate the learning outcomes for the course as well as the program outcomes. While the pros and cons of each form's suitability to accomplish the assessment task can be argued, they are presented here simply as examples of what can be done. In both cases it is evident that a high degree of interpretation of the results is needed to effectively summarize the findings and produce meaningful input to the evaluation phase of the continuous improvement process.

Figure 2. Example Alumni/Industry/Faculty Evaluation Form

Senior Project Evaluation

Name_____ Group Evaluated_____

1. Is the scope of the project clear from the oral presentation?

2. Was the project performed at the level you would expect from graduating seniors?

3. What is the most positive observation you can make of this group's efforts?

4. In what area do you think this group's project could use more work?

5. Are the plans and report of the quality you expected?

6. Is 'teamwork' evident? (Does not apply to all groups.)

7. Based on your observations today, what grade would you assign this group?

Figure 3. Example Peer Review Form

Senior Project Peer Review
Preliminary Engineering

Presentation:

1. **What grade would you give this presentation? Why?**

2. **Do you think the effort put into the project is properly reflected in the presentation?**

3. **What do you suggest this group do to improve their presentations in the future?**

Project:

1. **Has this group looked at all or most of the practical solutions to this design problem? If not, what alternative do you think they could have explored further?**

2. **In your opinion was sufficient data gathered and analyzed which in turn led to the solutions being presented? If not, what additional data or analyses would you like to have seen included?**

3. **Do you think this group spent (too much—just the right amount—not enough) time working on the plans? Do you think this group spent (too much—just the right amount—not enough) time working on the report?**

Other comments:

Implementation:

As stated, the assessment tools reviewed were examined in order to identify one or more data collection and reduction methodologies to input to the evaluation stage. Upon completion of our testing several of the tools were adopted. After identifying the linkages between the program outcomes and the learning outcomes of the capstone course we adopted a Survey of Learning Outcomes by the Instructor and a Survey of Learning Outcomes by Students. The form displayed as Figure 1 was used twice per semester for each group and the results summarized and reviewed upon completion of the semester. A numerical rating was calculated for each learning outcome for each set of surveys and the results tabulated.

In addition to the outcomes surveys both the Alumni/Industry/Faculty Evaluations using the form shown in Figure 2 as well as the Peer Evaluations of Individual Students and Design Groups using the form shown in Figure 3 were adopted. These assessment vehicles were used to verify or discount the findings of the Learning Outcomes Surveys. At first, we used this output only for verification of those items identified by the outcomes surveys.

Evaluations were conducted by alumni, industry representatives, and faculty at the final capstone project presentations at the end of the semester. At that time the design groups met one on one with these stakeholders and fielded questions about their work. Subsequently, each group delivered a 30 to 40 minute presentation at which they again answered questions posed by these stakeholders as well as any others in attendance. At the end of the activities the completed forms were collected and kept for use in the evaluation stage.

Likewise, students completed the peer evaluation forms after all of the course's activities were complete. Having worked with their peers throughout the semester and having served as interrogators both throughout the semester and at the final presentations, they were acutely suited to respond to the questions posed on the form. Once obtained, these forms like those from the other stakeholders were held for use during the evaluation phase of the continuous improvement process.

It is important to note that this represents the use of three independent assessment tools to provide three sets of data for use in evaluation. To obtain this data these tools required very little effort by the instructor and did not intrude upon the day to day activities of the course. We were very pleased that the capstone course could provide such a large input to evaluation with such little effort.

The Evaluation Phase:

Given the output of the assessments we met as a department to review the results. All faculty were required to attend to aid in the identification and remediation of identified program weaknesses. The process took the form of first looking at the learning outcomes identified by both the instructor and students learning outcomes surveys. Identified weaknesses in satisfying the learning outcomes were discussed as to their cause and possible solutions.

For example, when first implemented this process identified learning outcome 3, "...able to prepare technical reports," and learning outcome 6, "...can prepare meaningful progress reports" at level 3, "Not Sure" or less by both the instructor and the students. To see if this was a real concern we scrutinized the Alumni/Industry/Faculty evaluations. They showed that the written project reports were not of the quality expected by the evaluators. Furthermore, most of the Peer Evaluations stated that the design groups should have spent more time working on the report. All three assessment tools identified the students' written communication skills as less than adequate.

As a result, the faculty chose to seek improvements to the required technical writing course and implement more written reports throughout the curriculum. A goal of improving outcomes 3 and 6 in the capstone course was set with strategies developed to see measurable improvements. Specific courses were identified where increased report writing would be implemented and performance expectations in those courses discussed and set.

This process of weakness identification followed by remediation generation was repeated and continues. Examples of changes which have been initiated and/or accomplished as the result of this process include modifications to courses to include more topics dealing with construction methodologies and project management, and reordering of the curriculum. Many other changes aimed at providing measurable improvement to the program outcomes have been instituted as well.

Summary:

In summary, any program wishing to develop a comprehensive continuous improvement program should consider the capstone course as a major part of any model for successfully measuring program outcomes. When used in conjunction with the three assessment tools shown above, it provides extremely useful input to the evaluation process. It engages all stakeholders including alumni, industry representatives, faculty and students in the improvement process resulting in specific improvement strategies directed at specific courses in the curriculum and/or the curriculum itself.

The assessment is easy to accomplish in that it is not labor intensive nor does it intrude into the day to day activities of any course or courses. Yet, it provides substantial data to identify strengths and weaknesses in the program and provides verification of these results via multiple assessment tools. It is timely in that it is conducted every semester and it facilitates the evaluation process by keeping data handling to a minimum. Used in conjunction with common assessment tools such as employer surveys, graduate surveys, and industry advisory boards, it can be the cornerstone of any continuous improvement program.