Imbedding Assessment and Achievement of Course Learning Objectives with Periodic Reflection

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Abstract

By now, all engineering programs in the U.S. have a set of program outcomes (POs) that have been designed to meet the latest ABET requirements A critical issue related to implementing and sustaining the current ABET criteria is how to effectively use valuable faculty time to get the assessment data needed to evaluate a program and to make improvements in a program. In the program at North Carolina A&T, the POs are achieved using contributions from each of the courses in the curriculum. Each of the chemical engineering courses has a course-assessment committee that is responsible for developing and reviewing the set of learning objectives (LOs) for the course. The course instructor is responsible to design the course, teach the course, assess the student learning, assess the achievement of the LOs and write an assessment report to the course committee. The course-assessment committee is also responsible for reviewing the instructor's assessment that the course objectives were or were not met. The program outcomes assessment evaluates the LOs in the entire program to ensure that the POs are met.

To ensure the achievement of the course LOs, the instructor should prepare a course plan and view the course LOs as a list of skills and topics that the student must learn in the course. The course plan is the blueprint of how the course will be taught and how the LOs are to be achieved. In the past, an instructor prepared a course syllabus based on his interests and assessed student achievement based on his internal standard. Most instructors conscientiously presented the students with a series of lectures and exams that they felt were designed to meet a standard they set for the course.

Under the new paradigm, courses must be taught and assessed with the achievement of the course LOs and the program POs in mind. These new planning and documentation requirements have caused and continue to cause issues with faculty. If the continuing commitment of faculty is not maintained, any outcomes assessment plan will fail to produce the intended results.

In this paper, we suggest that faculty follow an "Imbedding with Periodic Reflection Model" and adopt outcomes assessment (OA) as a regular tool that they use to assess learning as they progress through the courses they teach. If they use OA as part of their normal method of teaching, they will have less resistance to completing a report and maintaining the OA plan for the program. To follow this "Imbedding with Periodic Reflection (IPR) Model," the instructor should develop a plan to teach the course so that students achieve the course LOs. They should then deliver the course and assess whether the LOs were met. Instructors should make periodic reflective comparisons between student learning and their course plan and adjust their plan if student learning was not achieved, adding supplemental instruction, further assignments and further assessment of the topic/skill. The reflective cycle is then repeated throughout the course. The authors use the method in a sophomore mass and energy balances course, a junior-senior process control course and a two-semester senior design sequence.

I. Introduction

The Engineering Accreditation Commission of the Accreditation Board accredits engineering programs in the U.S. for Engineering and Technology (EAC/ABET)[1]. Beginning in 2001, all programs are being evaluated based on the outcomes of the programs and the skills of their graduates. Each program's outcomes must also be linked to the objectives of the program and the missions of the College and University. In addition to a process for measuring and evaluating their outcomes, Universities must have outcomes assessment (OA) processes in-place to ensure the continuous improvement of the program. The continuous improvement processes must include input from the constituencies that the program serves.

In the program at North Carolina A&T, the POs are achieved using contributions from each of the courses in the curriculum. The responsibility for the evaluation, maintenance and improvement of our courses and curriculum lies with the faculty. The processes that we have put into place detail how the faculty monitors our courses and curriculum. Each of the chemical engineering courses has a set of course learning objectives (LOs) that are maintained and assessed by a course committee. The course instructor is responsible to design the course, to teach the course, to assess the achievement of the course LOs and to write a report to the course committee. The most important part of our continuous improvement processes is the set of course loops in where faculty assess student learning in each of our courses. The responsibility for the improvement of the outcomes from our courses lies with the course assessment committees. The flow model depicting the course improvement loop is given in Figure 1.

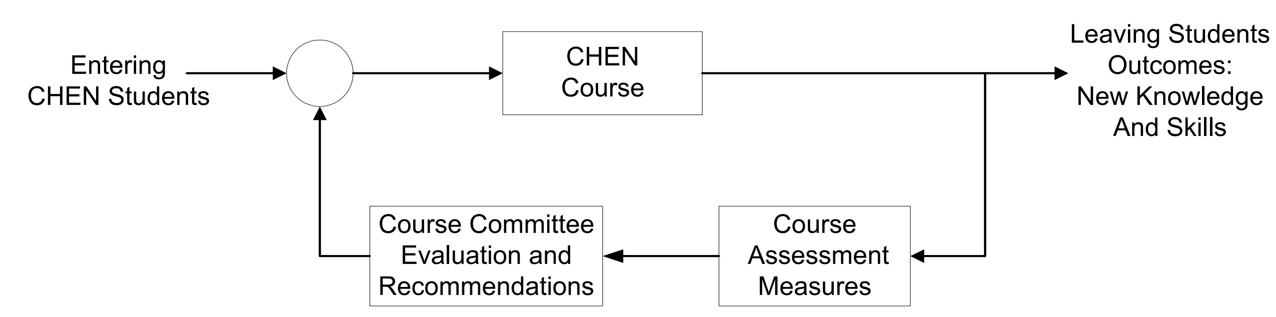

Figure 1. Course Improvement Process Model

Under the new accreditation criteria, Universities have more freedom to offer innovative programs than before. They must convince ABET, however, that their graduates have the set of skills and abilities that are required by the criteria. If a department convinces ABET that the criteria are met, their programs are generally accredited. This exciting new paradigm in engineering education is presenting many challenges and opportunities for faculty.

The new criteria have created a new order of doing business in engineering colleges. Tener[2] states that "the greatest challenge to developing an effective outcomes assessment system is the institutional culture of the faculty." The most difficult task for the implementation of an assessment plan is to get positive faculty support and continuous input. Shaeiwitz[3] states the challenge as follows:

> "Implementation of an assessment plan in which faculty provide and respond to feedback will be a difficult task. At most institutions, it will require a significant paradigm shift in faculty behavior. It is unclear how to effect such changes; there are conflicting opinions on whether faculty is motivated by intrinsic or extrinsic factors. ***But, if this problem is not dealt with forthrightly at the outset, implementation of an effective assessment plan is doomed***."

It is generally recognized[4, 5] that the factor most predictive of success in faculty motivation is depth of knowledge about the personal characteristics of the faculty members. Although it is difficult to generalize how to motivate faculty to actively participate in program assessment, the literature provides some guidelines as to what methods are most likely to be successful. Faculty are most often intrinsically motivated and some limited positive extrinsic motivation possibilities have been reported.[5-8] Financial rewards are not likely to sustain an assessment program nor are the rewards likely to be sustained. King and Schimmel[9] summarized the following list of intrinsic rewards to use in motivating faculty to maintain a successful assessment process:

- Seeing positive changes in student performance attributable to faculty actions
- The challenge of continual integration of new information into a course
- Satisfying relationships with students
- Satisfying relationships with colleagues
- A sense of autonomy
- Intellectual stimulation.

In the academy, the faculty has always been resistant to change. An important principle for the successful implementation of an assessment process is to minimize the commitment of faculty time outside of their normal course preparation. In developing an assessment process that utilizes these intrinsic rewards, one needs to be mindful that faculty intrinsic motivation is reinforced by slightly unbalancing the challenge to them and the skills needed to meet the challenge. Thus, whenever faculty are being asked to do something new, one must be careful that the new tasks are within their comfort zone.

II. Imbedding with Periodic Reflection Model

The intent of the IPR teaching model presented here is to help faculty make the assessment of course learning objectives part of their teaching culture. The model provides a prescription to for faculty to make student achievement of course learning objectives a normal part of their course teaching along with the selection of content, teaching methods, and how student learning may be improved. We suggest that faculty adopt assessment as a regular tool that they use to evaluate student learning of LOs as they progress through teaching their courses. If OA becomes a part of the normal method of teaching, faculty will have less resistance to sustaining the OA plan for the program.

To follow this "Imbedding with Periodic Reflection Model," the instructor must develop a plan to teach the course so that students achieve the course LOs. The plan should also include breaking the course into several parts that include periodic teaching and assessment. The instructor should deliver the first section of the course and assess the whether the LOs planned for the first section were met. The instructor should then make a reflective comparison between student learning and the course plan. During this reflection, the instructor compares their teaching plan to the achievement of the LOs. If exam results demonstrate that students learned the topic/skill, the LO is achieved. Even though the LO has been achieved, the learned skills should be reinforced to insure retention as the course progresses. If exam results demonstrate that students have not learned the topic/skill, the LO has not been achieved. In this case, the plan must be revised until student learning of the LO is achieved. Instructors must make adjustments to their teaching plans just as they expect students to make adjustments in their learning. The revised plan could include adding supplemental instruction and making more assignments covering the LOs not met. The revised plan must include further assessment of the topic/skill. The cycle is then repeated throughout the course.

A block flow model depicting the IRP model, for one section of a course, is given in Figure 2.

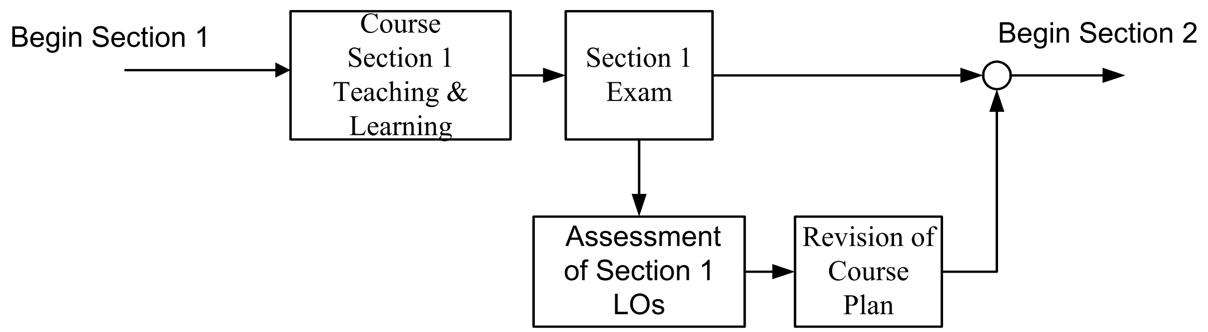

Figure 2 Block Flow Diagram for the IPR Model

A plan for teaching a course using the IPR model would include cycles consisting of

- Teaching part of the course for targeted LOs
- Giving an exam to assess achievement of the LOs
- Evaluating the exam
- Assessing student achievement of the targeted LOs in the course section
- Providing feedback to the class about their achievement and course progress
- Reflection and modification the plan based on the results

III. IPR Model—An Example of its Application

The authors have used the IPR method in a sophomore mass and energy balances course, a junior-senior process control course and a two-semester senior design sequence. The assessment of student learning through the achievement of the course LOs is part of their normal teaching activity. In most of our courses, students have an opportunity to complete an optional learning portfolio to demonstrate their achievement of the LOs. The rubric for the learning portfolio is shown in Table 1. Students complete the portfolio so that their lowest grade is dropped.

The IPR method is illustrated for the first section of our Process Control course that was taught during the spring semester to a mixture of junior and senior chemical engineers. The course plan includes 23 LOs that are assessed using three mid-course exams, a final exam, eight Control

Station[10] laboratory experiments and a plant-wide, process control, configuration project.

Table 1 Rubric for the Course Learning Portfolio

Completion of a Course Learning Portfolio is an optional means for you to demonstrate that you have learned all course learning objectives by the end of the course. The grade on the Course Learning Portfolio can be used to substitute for your second lowest grade. Since the portfolio replaces an examination, it was evaluated critically to assess comprehensive learning of each objective. Simply compiling your group's homework and your individual problems will not do it. The Course Learning Portfolio should consist of homework problems and other evidence to demonstrate that you have mastered the learning objective and to demonstrate the difficulty level of the problems you can solve. Present items that are unique to you! The portfolio must be submitted by the final exam and must contain all of the following:

- A binder with a section for each of the expanding list of course learning objectives
- Each section must include the evidence that demonstrates your achievement of the learning objective
- A statement summarizing what the objective means, its importance to the course and your learning of the objective and your analysis of your achievement level.

Portfolios submitted late or without all of the required items will not be evaluated.

Portfolio Grading Rubric

I. For a Grade of A, 90% or higher
Portfolio is submitted on time. Portfolio contains all required sections.
Portfolio is neatly organized.
Solid evidence is provided for all course learning objectives
Evidence demonstrates capability to solve moderately difficult level problems for **all** learning objectives

II. For a Grade of B, 80 to 89
Portfolio is submitted on time. Portfolio contains all required sections.
Portfolio is neatly organized.
Evidence is provided for all learning objectives
Evidence of capability for solving minimum difficulty level problems for all LOs and moderately difficulty level problems to 50% of the learning objectives

III. For a Grade of C, 70 to 79
Portfolio is submitted on time. Portfolio contains all required sections.
Portfolio is neatly organized.
Evidence is provided for all 16 learning objectives
Evidence of capability for solving minimum difficulty level problems relaxed to 75% of the learning objectives
Evidence of capability for solving moderately difficulty level problems relaxed to 25% of the learning objectives

IV. For a Grade of D, 60 to 69
Portfolio is submitted on time. Portfolio contains all required sections.
Portfolio is neatly organized.
Evidence is provided for all learning objectives
Evidence of capability for solving minimum difficulty level problems relaxed to 50% of the learning objectives

Concepts taught and learned in a process control course are highly dependent on topics learned earlier in the course. It is, therefore, very important that students fully achieve the LOs as the course proceeds. In the first section of the course, the plan was to provide lectures, laboratory experiences, homework assignments and classroom discussion so that students can achieve LOs 1-2. The course material includes the concept of a feedback control system and the parts of a control system. In addition, they must also review and dust-off the skills learned in applying Laplace transforms to the solution of initially inert, linear differential equations with constant coefficients. In addition, they must understand and appreciate the reality that real processes are neither simple nor linear. Finally, they must be convinced that linear concepts are very adequate to the understanding of a regulatory control system. The LOs covered in the first section of the course, 1-6, are listed in Table 2.

Exam 1 was designed to assess achievement of the first six LOs. The authors recommend that each LO be assessed using multiple questions or problems. The A&T outcomes assessment plan requires at least three assessment measures for each LO and that two of the measures be quantitative. The rubric for achievement of an LO is set by the course committee, but is about 70%. The authors also consider the fraction of the class achieving the standard as an assessment measure. Student performance on each exam question is recorded and assessed individually so that each LO can be assessed separately.

Table 2 Study Guide and LOs assessed on Process Control Exam 1

<u>Course Learning Objectives Covered</u>: Exam 1 is for you to demonstrate your accomplishment of the following learning objectives:

1. I can specify a feedback control loop to regulate temperature, pressure, level, pressure and composition.
2. I can apply Laplace transform methods, including transfer functions, the initial-value theorem, the final value theorem, and the time-shift and transform-shift theorems to solving process dynamics and control problems.
3. I can use Laplace transforms to determine the response of first-order processes (FOPDT) to step and pulse disturbances.
4. I can use process response data to identify process transfer functions, linearity and nonlinear effects.
5. I can linearize a function using a Taylor series expansion and use it to linearize a process model.
6. I can determine parameters for an FOPDT model using transient response data.

EXAM TOPICS
SAMPLE Exam problems—from old exams

Table 3 summarizes the results for assessing student learning of LOs 1-6. Individual student's scores are not included. The end of a course section is the time for assessment, reflection and revision for both students and instructor.

Table 3 Process Control Exam 1 Assessment

	Question No./Score											
Student/Item	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
% of Students Scoring at Least 70% on Question	**43**	**76**	**62**	**71**	**62**	**48**	**52**	**90**	**24**	**67**	**38**	**72.1**
Class Average on Question, %	**59**	**78**	**79**	**80**	**67**	**64**	**72**	**92**	**53**	**74**	**74**	
LO Assessed by Question	**1**	**2**	**2**	**3**	**3**	**2**	**5**	**1**	**2**	**6**	**4**	
Was LO Satisfied?	?	Yes	Yes	Yes	?	?	Yes	Yes	No	Yes	Yes	

After receiving feedback on their Exam 1 performance, students are asked to assess, reflect and revise their individual learning behavior in the course. They are asked to consider their effort and their use of all the support available to them. In addition, they are asked to assess their performance within their study group. Similarly, the instructor reflects on student achievement and makes necessary revisions to the course plan. Based on the Section 1 assessment, supplemental instruction was provided on configuring a schematic for a feedback control loop, building input disturbances and some other Laplace operations.

IV. Summary

In this paper, we have presented a teaching model for gaining faculty involvement for successfully maintaining outcomes assessment processes in an engineering program. In our view, the essential ingredient to maintaining effective outcomes assessment processes lies with imbedding the assessment process in the teaching culture of the faculty. The model presented here provides a mechanism for faculty to embrace assessment by using the process to help them improve the courses they teach. The model can serve as a guide for faculty in other engineering programs to use for the continuous improvement of their courses.

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