Achievement of Course Learning Objectives: An Assessment Tool that Promotes Faculty Involvement

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Introduction

During our department’s preparation for an ABET EC 2000 visit, we likely considered issues similar to those addressed by other departments during their EC 2000 preparations. By way of background, over the previous several year period, under guidance by experts at Ford Motor Company, we had gained valuable experience attempting to introduce the concepts of continuous quality improvement (CQI) into our academic programs. Through this early exposure, we had become firm believers that the general notion of continuous improvement could be applied in an academic setting. Also helpful to our EC 2000 preparatory work was the fact that we had a tradition of investing considerable time, effort and resources in our undergraduate program and were committed to maintaining a strong program. We recognized that to bring about improvements, specific measures had to be identified so that one could quantify the results of changes made to a program and were thus willing to go through the process of identifying appropriate measures and gathering data. We were more than willing to once again invest time to organize our self-study report and gather samples of student work and other supporting documents so that our next ABET visit, our first under the new EC 2000 criteria, would go very well.

It was clear, however, that to satisfy EC 2000 more of our time would be required than had been the case with previous ABET evaluations, and one troubling apprehension began to emerge: would there be a meaningful return on the investment of our time. This initial apprehension spawned three primary concerns. How could we sustain our continuous improvement process during the years following the ABET visit? How could we maintain faculty enthusiasm over an extended period? How could we use what we had learned and apply the processes we had developed to improve our graduate programs? We realized that our challenge was twofold: first to handle EC 2000 well, and second to structure an overall process-improvement approach so that faculty members would recognize that we would likely be getting a positive return on the time we were investing in our BS program, year after year. It was clear that it would not be those of us who were already committed and who were leading the EC 2000 effort who would ultimately make the judgment of whether or not we were in fact getting a positive return on our time, but rather our departmental colleagues.
This paper describes what has emerged as the key element in our overall process-improvement structure, how this element evolved, how it is woven into the core operations of our department, and how it is being used in efforts to improve our MS and PhD programs.

Program Setting

Wayne State University is listed under the heading of Carnegie doctoral/research universities-extensive. It had a ranking of 68 in the National Science Foundation listing of research & development expenditures at universities and colleges overall for fiscal year 2000, and a ranking of 48 among public universities and colleges. This means our faculty members are expected to carry out research programs and win external research funding, in addition to handling teaching and service tasks.

Our BS program in mechanical engineering had a head count of 270 students Fall Semester of 2001. Of this number, 148 were listed as full-time students, but that figure is based on the credit hour load taken by students and understates the number of our students who work 20 or more hours per week while attending school. Our graduate program is larger than our undergraduate program and encompasses majors in mechanical engineering and biomedical engineering. Fall 2001 headcount figures for the MS and PhD programs were 416 and 61, respectively. Most of our MS students are part-time.

Expectations of building faculty enthusiasm for EC 2000 had to be tempered with the realization that faculty also had research programs to lead and substantial graduate program responsibilities.

Course Learning Objectives

In our previous work applying CQI to our program, we had developed first, second and third level objectives for several of our undergraduate courses. As we considered the letter and spirit of EC 2000, it became clear that we could build from those previous CQI efforts to set up course objectives and in this fashion could build up specific course learning objectives for each of the thirteen courses taught by Mechanical Engineering faculty that were required in the BS program in ME. Our thought was that this collection of course learning objectives would then be the main tool we could use to establish that any graduate of our program had satisfied our Program Outcomes. This discovery, however, came about only after a number of twists and turns.

The first steps in EC 2000 seemed straightforward, especially since the process of defining our Program Outcomes had gone quite smoothly. In our earlier CQI work, we had established BSME program goals, and our first breakthrough came when we realized these goals would be appropriate, with only slight modification, to serve as the Program Educational Objectives called for in EC 2000. Program Outcomes quite naturally followed from these Program Educational Objectives, although we did have to make minor adjustments to make certain our Program Outcomes would satisfy items (a) – (k) in Criterion 3 of EC 2000.

The next step also seemed straightforward initially. We would just use the matrix approach adopted by other programs\(^1\). We listed our Program Outcomes in rows and our thirteen required courses in columns. We then, for each course, just checked off the Program Outcomes that we
expected the course to impact. In this way, superficially, it looked like we were covering all Program Outcomes. Flaws in this reasoning soon became apparent, however. Although checks might appear in the appropriate cells of the matrix, clearly different courses would cover a specific Program Outcome to varying degrees of thoroughness. To resolve this difficulty, we modified the matrix so that the degree of coverage a course gave to an Outcome that had been checked would be indicated by High, Medium, or Low. But then questions began to be posed about precisely how a course was giving High (or Medium or Low) coverage to a Program Outcome: What, in fact, was being done in the course? What were the students learning, and how could we demonstrate that students were, in fact, learning? Through this tortuous process we were led to adopt course learning objectives as the “currency” by which we would assess what specific contributions a course was making to the overall satisfaction of our Program Outcomes. Here again, though, there were surprises in store.

As we began to review specific course learning objectives proposed by course instructors, it soon became apparent that material we thought was given substantial coverage in a course was not, in fact, listed among the course learning objectives. With the preliminary course information we had in hand, for example, it was clear we could not demonstrate that students were being given adequate coverage of design of experiments. It also became clear that there was not always a strong correlation between the specific course learning objectives for a course and the measures used to determine student performance in the course.

Even at this early stage in our evolution, however, one benefit of “defining” a course by its specific course learning objectives became clear: this provided the best mechanism we had encountered for allowing mechanics faculty to understand what was being done in individual thermal fluids courses, and conversely. Although it may not have been crystallized early on, one lasting achievement of our work on EC 2000 is that now all of our courses, those at BS, MS and PhD levels, have course learning objectives. Further, all courses through the MS level follow the ABET process that will be described later in this paper.

It eventually became clear to us during our EC 2000 planning stage, that the process of reviewing proposed course learning objectives for each of our required thirteen courses and then, as a full faculty, deciding whether to approve them, could lead us to many hours of work and discussion, with only a slight prospect of final resolution. Signs of impatience and some degree of frustration among faculty members surfaced, and it was evident people were becoming concerned about the amount of time EC 2000 was going to require. The solution was to refer the procedure for approval of individual course learning objectives to our Course Grouping Coordinators.
Course Groupings

For many years we had utilized a departmental structure whereby each and every Mechanical Engineering course was assigned to one of six Course Groupings. A faculty member could chose to be associated with as many Course Groupings as he wished, and the members of the Course Grouping elected the Course Grouping Coordinator. The six Course Groupings are: Solid Mechanics, Acoustics, Dynamics, Vibrations & Controls, Thermal/ Fluids, Design/ Manufacturing, Engineering Mathematics, Biomedical Engineering.

All of the thirteen courses required for the BSME are in one of the first four Course Groupings in the list given above. The remaining two Course Groupings are composed entirely of MS and PhD level courses. The two key roles of the Course Groupings that existed at this point in time of the evolution of our EC 2000 process primarily impacted our graduate programs. The Course Groupings were to identify what would be the core courses in MS and PHD program options involving their Course Grouping and to define the frequency of offering of each course within their Course Grouping. To do this, faculty members of each Course Grouping had to examine the totality of courses within their Course Grouping. To maximize coverage, they wanted to minimize overlaps of courses, while making certain that critical material was being covered within the core courses they had identified. By setting the frequency of course offerings, the Course Groupings were essentially defining teaching loads of faculty who belonged to their Course Grouping. This later point was extremely important, since with 24 total faculty members, our ME department was of only moderate size, and had to be very selective in what courses we offered. Further, because of research commitments, teaching loads had to be kept reasonable so our faculty could compete for external funding. Finally, since so many of our undergraduates are part-time students, we offer each of the thirteen required BS courses at least twice per year, and the faculty had resolved that some 80 – 90% of these undergraduate course offerings would be taught by full-time faculty members. The flexibility of what graduate courses we could offer was thus limited, and as a consequence the Course Grouping Coordinators were charged with significant responsibilities. If their Course Grouping wanted to offer some sort of specialized graduate course, they had to work out who would teach it and what would happen to the course that person had been assigned to teach. (We work on rolling four-year teaching schedules for faculty. We try not to alter a faculty member’s teaching assignment unless the initiative comes from the faculty member. This is especially important to junior faculty, but allows all faculty members the security of knowing what they will be teaching in the future. They can thus invest the time it will take to offer a strong course.)

We thus handled the problem of determining course learning objectives for each required undergraduate course by simply turning the problem over to the well-established structure of Course Groupings that had served us well for years. The Course Groupings arrangement also came to the rescue when we floundered in developing a process for assessment.
Assessment

From the very outset, we had some elements of an assessment process in place, or nearly in place, but these were merely the elements we could accomplish by surveys of constituents. We had communicated regularly through department newsletters with graduates and friends of the department, and it seemed reasonable that we could use this vehicle to survey recent graduates to provide a measure of the extent to which our Program Educational Objectives had been achieved. The department chair had regularly conducted interviews with graduating seniors, and we decided we could simply expand this process to include a written component that would give us a measure of how well we were achieving both our Program Educational Objectives and our Program Outcomes. Additionally, we decided to survey students in a third-year design class to see to what extent they felt our Program Outcomes had been covered in their individual cases. The thought here was that if we found glaring problems, we would have one year left in the students’ program to take corrective action. At some stage we also decided to use a student survey regarding the specific course learning objectives. We recognized that students would not necessarily know what material should be covered in a course, but we were confident that students could identify whether an appropriate degree of effort had been expended to achieve a course learning objective. Although there were iterations along the way, the basic format for this survey is to take each of the specific course learning objectives listed in the syllabus for the course and use them to form questions: “This course has improved my ability to (insert learning objective)”. Students complete the survey using a five-point scale, with “Strongly Disagree” corresponding to 1 and “Strongly Agree” to 5.

Our quandary was how to go beyond student surveys for assessment. Eventually we focused on the process we would use so that the course instructor could assess the learning that had taken place in her course, and then what we would do with the result. The solution was again to utilize our well-established structure of Course Groupings.

Extent to which course learning objectives were achieved

We will give a specific example to illustrate the key element of our assessment process that emerged from our preparatory work for EC 2000. We require that a report be filed for each BS and MS level course taught. The report titled: “Instructor’s Assessment of Extent to which ME 2060 Course Learning Objectives Have Been Achieved Fall Semester 2002” is for an entry level course and provides an example of such a required report. For each of the course learning objectives that had been listed in her syllabus, the course instructor must describe what measures she had used for a particular learning objective to assess the extent to which that learning objective had been achieved (quiz or exam scores, performance on design projects, laboratory reports, oral reports, etc.), what actual scores the students had achieved based on this measure, and, from the student surveys, report to what extent the students thought course learning objectives had been achieved. The “Instructor’s Assessment of Extent…” report concluded with a listing of changes in the course or approach taken in teaching it that the instructor recommended to improve learning.

Our process requires that each such “Instructor’s Assessment of Extent…” course report go to the Course Grouping to which the course is associated. The Course Grouping Coordinator then
calls a meeting of all faculty associated with the Course Grouping and they review the “Instructor’s Assessment of Extent…” reports for all courses in their grouping. They can suggest minor changes in course learning objectives, make subtle adjustments in what material is to be covered in each of their courses or take other action restricted to their grouping level. For any change that would impact courses outside of their grouping or the entire program, the Course Grouping Coordinator must report to the entire ME faculty and gain their approval of the change.

Process to assess achievement of course learning objectives

To summarize, the basic ingredients of this process are the following:
1) All required BS-level courses are assigned to one of the four Course Groupings that contain undergraduate courses;
2) Course Learning Objectives for each course are published in the course syllabi;
3) Students complete a survey stating to what extent they felt the instructor addressed learning objectives;
4) On completion of a course, the instructor files a report for her course “Instructor’s Assessment of Extent to which Course Learning Objectives Have Been Achieved” in which she spells out the measures used to determine if learning objectives were achieved and proposes steps to improve learning the next time the course is offered;
5) The instructor’s report and student surveys go to the associated Course Grouping Coordinator who leads faculty discussions of results obtained from all courses in the Course Grouping and develops proposals for course changes that are submitted to the Undergraduate Program Committee.

Discussion

Perhaps the most important lesson that we learned in preparing for EC 2000 was that faculty involvement would be enhanced if we built on the existing mode of operations within our department. Although not recognized at the outset of our work, the utilization of our structure of Course Groupings allowed faculty to be involved with EC 2000 in a very meaningful way, but in a fashion entirely consistent with their previous activities. Further, use of our Course Groupings has allowed us to carry over in a very natural fashion the process developed to improve the BS program to the task of improving our MS program. We define MS courses in terms of their learning objectives, we review the instructor’s assessment of the extent to which the learning objectives were achieved, and we use these results to make improvements to MS program options.

For completeness, the entire twelve-month cycle of the assessment process we have adopted is outlined below.

General Twelve-Month BSME Program Assessment Cycle

- Early May – Based on their annual, joint review of all assessment material gathered over the previous 12 months, the Industrial Advisory Committee (IAC) and the Student
Advisory Committee (SAC) will recommend changes to the BSME program, to individual courses, or to the ME assessment process.

- Early September – An Annual Report to Constituents will be distributed and published on the web. The Annual Report to Constituents will summarize assessment data collected over the previous year and will include the ME faculty list of proposed changes to the BSME program, to individual courses, and to the ME assessment process to be adopted for the coming academic year. Comments will be solicited from all constituents.
- Early September – Course Learning Objectives will be published in Fall Semester course syllabi.
- Early October - Based on inputs from constituents following publication of the Annual Report to Constituents and on recommendations of the IAC/SAC from their annual review, the ME Department will distribute and publish on the web details of the assessment process to be used for the academic year in progress.
- Early December – Students will complete individual Fall Semester course learning objectives questionnaires, based on the course learning objectives that were published in the course syllabi.
- Early December – Industrial experts will attend presentations of student project design teams in ME 4300 Thermal Fluid Systems Design and ME 4500 Mechanical Engineering Design II and evaluate student work.
- Early December – Surveys of graduating seniors will be collected and exit interviews of all students from the Fall Semester capstone design course ME 4500 will be conducted by the Department Chair.
- December/January – A survey of BSME graduates over the last five years will be mailed out. (TO BE DONE ONLY EVERY THIRD YEAR)
- December/January – Course instructors will complete “Instructor’s Assessment of Extent to which ME xxxx Course Learning Objectives Have Been Achieved” and “Instructor’s Assessment of Extent to which ME xxxx Has Contributed to Meeting BSME Program Outcomes” for all ME courses through the 5000-level that they taught during the Fall Semester.
- Early January – Course Learning Objectives published in Winter Semester course syllabi.
- January/February – Faculty from each of the four Course Groupings will review individual instructor assessments and plans of action, including comments based on students’ recently completed Fall Semester questionnaire responses, from all courses within their individual Course Grouping. The Coordinators of each Course Grouping will send a summary of changes they suggest to the ME Undergraduate Program Committee. The ME Undergraduate Program Committee will send to the entire ME faculty any recommendations that require approval by the entire faculty.
- April – Students will complete individual Winter Semester course learning objectives questionnaires*, based on the course learning objectives published in the course syllabi.
- April - Industrial experts will attend presentations of student project design teams in ME 4300 Thermal Fluid Systems Design and ME 4500 Mechanical Engineering Design II and evaluate student work.
- April – Students in the third year design class ME 4250 will complete a survey related to the extent to which they think they have achieved the BSME Program Outcomes.
• April - Surveys of graduating seniors will be collected and exit interviews of all students from the Winter Semester capstone design course ME 4500 will be conducted by the Department Chair.
• April/May - Course instructors will complete “Instructor’s Assessment of Extent to which ME xxxx Course Learning Objectives Have Been Achieved” and “Instructor’s Assessment of Extent to which ME xxxx Has Contributed to Meeting BSME Program Outcomes” for all ME courses through the 5000-level that they taught during the Winter semester*.
• April/May - The ME Undergraduate Program Committee will review individual instructor assessments and plans of action, including comments based on students’ recently completed Winter semester questionnaire responses. The ME Undergraduate Program Committee will send to the entire ME faculty any recommendations that require approval by the entire faculty*.
• Throughout Academic Year – Surveys of Employers of ME co-op students will be reviewed.
• Throughout Academic Year – Input from campus interviewers of BSME graduating students will be gathered.
• Early May – At a joint meeting, the IAC & SAC will review all assessment data collected, with the charge that they are to recommend whatever changes they think to be in order to individual courses, the BSME program, or the Assessment process.

* Note that students’ questionnaires, instructors’ assessments and faculty committee reviews will be carried out for each course through the 5000-level once per year, except that every sixth year, during the years preceding ABET visits, these activities will take place both Fall and Winter semesters.

Bibliographic Information

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