UNDERSTANDING AND IMPLEMENTING ABET ENGINEERING CRITERIA 2000

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Abstract

The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology has established new criteria for the accreditation of engineering programs. The new criteria, called Engineering Criteria 2000, are significantly different from the old criteria. In the past, the accreditation criteria focused almost entirely on resources and curriculum. In contrast, EC 2000 is a remarkably shorter, less prescriptive, much broader document that also focuses on processes and outcomes.

EC 2000 has eight criteria which apply to undergraduate engineering programs. Two of these, Criterion 2, Educational Program Objectives, and Criterion 3, Program Outcomes and Assessment, are central to the reform of engineering education. Focusing on academic processes, Criteria 2 and 3 require, among other things, that each program have in place a system of ongoing evaluation that demonstrates the achievement of educational objectives and program outcomes and applies the results to continuous improvement. This requirement for continuous improvement represents the most critical difference between the old criteria and EC 2000, and may well be the most difficult requirement for engineering programs to meet.

This paper discusses some of the new ABET requirements and the academic processes they call for, presents a model established at Loyola Marymount University which integrates these processes into a system for continuous improvement, comments on quality teaching and continuous improvement, and reviews some lessons learned from early attempts to implement EC 2000.

I. Glossary

Processes:	Linked, interactive sets of activities which, taken together, comprise a system of continuous program development, assessment and improvement.
Program Constituency:	A group of people with common expectations of an educational program.
Constituencies' Needs:	Benefits which a program's constituencies expect to realize in return for their investments in an educational program.
Program Educational	Broad statements consistent with institutional missions and based on

Objectives:	program constituencies' needs which describe the values, characteristics, and capabilities graduates are expected to exhibit after completing the program curriculum.
Program Outcomes:	Statements based on program educational objectives which describe the knowledge and skills graduates are expected to have after completing the program curriculum.
Program Curriculum:	An organized set of courses and labs, culminating in a major design experience, designed and integrated to logically develop a student's knowledge and skills in preparation for professional practice.
Course Learning Objectives:	Statements based on program outcomes which describe the specific knowledge and skills students are expected to acquire in individual courses within the program curriculum.
Performance Standards:	(Syn: Performance Criteria) Clear, measurable definitions of the critical performance levels required to achieve program educational objectives, program outcomes or course learning objectives.
Measurement Tools:	Methods and instruments designed for the generation, collection, organization and analysis of data for assessment and/or decision making.
Data:	Quantitative and/or qualitative factual information.

II. Introduction

In 1996, the Accreditation Board for Engineering and Technology (ABET) approved a new set of engineering accreditation criteria, called Engineering Criteria 2000 (EC 2000). These new criteria will be used by the Engineering Accreditation Commission (EAC) for accrediting engineering programs and will be phased in over a three year period beginning fall 1998. During the first three years programs visited will have the option of using either the new or the old criteria. Full implementation will begin fall 2001 meaning that all programs visited beginning fall 2001 must use the new criteria.

The new criteria are significantly different from the old criteria. The most obvious difference when comparing the two criteria is the length. The old criteria are twelve pages long written in two-column format and in small print. In contrast, the new criteria are only three and a half pages long and are in a readable font size. Much more important than their brevity, though, is that the new criteria are far less prescriptive. Also, the emphasis of the old accreditation criteria was almost exclusively on resources and curriculum. When reviewing programs, evaluators focused on such things as faculty qualifications, curriculum details including the number of units of mathematics, basic sciences, engineering science and engineering design, and adequacy of laboratory facilities and engineering equipment. The methods used to review a program under the old criteria were sometimes referred to as "bean counting." EC 2000, on the other hand, is a much broader document that also addresses processes and outcomes.

This paper will not cover all of the requirements published in Engineering Criteria 2000. Suffice it to say EC 2000 has criteria that fall under eight rubrics: Students; Program Educational Objectives; Program Outcomes and Assessment; Professional Component; Faculty; Facilities; Institutional Support and Financial Resources; and Program Criteria. The second and third criteria, Program Educational Objectives and Program Outcomes and Assessment, in essence, require each program to: 1) establish educational objectives consistent with the institutions overall mission and the needs of its constituencies; 2) implement a curriculum and processes that demonstrate that these educational objectives and their associated program outcomes are being measured and achieved; and 3) initiate a system of ongoing evaluation that applies the results to continuous program improvement. These requirements are central to the reform of engineering education today. The processes necessary for their implementation will be a primary focus of this paper.

The third requirement above represents the most critical difference between the old criteria and EC 2000 and will probably be the most difficult for engineering programs to meet. Afterall, it is one thing to say that you are committed to continuous improvement, but it is quite another to show that processes for improvement are in place which are effective and which involve all of the program's faculty and various constituencies. Continuous improvement requires that a hierarchy of program educational objectives, program outcomes and course learning objectives be developed, their achievement levels assessed, and a feedback mechanism integrated to continuously improve their achievement. This requires full involvement of the faculty for several years prior to an accreditation visit as well as their continuous involvement after the visit. The most critical area of faculty involvement, however, will be the continuous improvement of classroom teaching and the curriculum. Without quality teaching and a strong curriculum, course learning objectives will not be achieved and, if they are not, the higher program outcomes and educational objectives they support will also fail.

The following sections discuss twelve academic processes designed to satisfy the requirements of EC 2000 Criterion 2 and Criterion 3, present a general model established at Loyola Marymount University that integrates these processes into a system for continuous improvement, describe the role continuous improvement plays in increasing the quality of teaching and learning, and review some lessons learned from initial attempts to implement EC 2000.

III. Program Development, Assessment and Improvement System

Much of what follows was adapted from a paper authored by Aldridge and Benefield (see References). It serves as an excellent starting point for understanding and implementing EC 2000.

Described below are twelve processes that comprise a system for the continuous development, assessment and improvement of an engineering program in accordance with EC 2000. Figure 1 diagrams these processes and shows how they might logically flow in the development of a new program. Established programs, of course, will need to introduce many of these processes simultaneously, while continuing to offer courses within the curriculum. To better understand the processes that are outlined below however, they will be presented as if a new engineering program is being developed.

The first step is to determine constituencies' relevant needs (Fig. 1, #1). A *constituency* is a group of people with common expectations of an educational program. A school that is developing a new engineering program must determine who their constituencies are, what each group expects to get from the program, and which of these needs can be reasonably fulfilled. Students, employers, industrial representatives, state officials and graduate/professional school representatives are just some examples of engineering program constituencies.

Once constituencies' relevant needs have been selected, the program educational objectives must to be developed (Fig. 1, #2). *Program educational objectives* are broad statements consistent with institutional missions and based on the program constituencies' needs. They describe the values, characteristics, and capabilities that graduates are expected to exhibit after completing the program curriculum. Although broad in scope, educational objectives must also be measurable to the extent that valid assessments can be made of their level of achievement.

Next, program outcomes need to be developed (Fig. 1, #3). *Program outcomes* are statements based on the program educational objectives. They describe the knowledge and skills graduates are expected to have after completing the curriculum. These must encompass, at the very least, the 11 (A-K) outcomes specified in EC 2000 Criterion 3. Program outcomes must also be measurable so that valid assessments can be made of their level of achievement. It is highly recommended that a matrix be developed to ensure that every program educational objective is addressed by at least one program outcome.

Once program outcomes have been developed, a set of courses that will meet the program outcomes and program educational objectives can be designed, i.e., the curriculum can be developed (Fig. 1, #4). The curriculum must also meet the requirements of EC 2000 Criterion 4. As part of the curriculum development process, learning objectives need to be developed and systematically assigned to specific courses (Fig. 1, #5). *Course learning objectives* are statements based on program outcomes. They describe the specific knowledge and skills students are expected to acquire from each course and lab in the curriculum. They, too, must be measurable so that valid assessments can be made of their level of achievement. Again, a matrix would be an excellent aid to ensure that every program outcome is addressed by at least one course learning objective. Course learning objectives should be clearly stated in the syllabus for each course and laboratory and tied to the mastery of at least one of the course topics.

It is very important to understand that although courses may be taught by individual faculty members, no one individual can be "flying solo" when it comes to curriculum development. Faculty must work together as a team in coordinating the program curriculum to optimize the achievements of their students and graduates. Everyone must know what the others are doing so that each course contributes maximally to the achievement of program outcomes, and so that the curriculum, as a whole, satisfies the program educational objectives. It is highly recommended that an organizational chart be developed showing the relationship of each course in the curriculum to course learning objectives, program outcomes, and program educational objectives. Also a complete set of course and lab syllabi should be updated and published on a regular basis by the program faculty and made available to all program constituencies.

In most cases, however, individual faculty will be teaching courses, and it will be up to that person to assess and grade student performance (Fig. 1, #6). Furthermore, it will be primarily up to the individual faculty member to ascertain whether course learning objectives are being met. It would be very productive, though, for program faculty to consult with their peers and collectively determine the level of achievement of course learning objectives for each course in the curriculum.

After each course has been completed and the achievement of course learning objectives has been assessed, faculty, both individually and collectively, must then use the assessment data to make calculated changes to improve the achievement levels of course learning objectives (Fig. 1, #7). It is important to understand that it is improvement of the achievement levels of course learning objectives that is the desired result of this process, and not the refinement of the course learning objectives per se. This refinement will take place as the development processes are revisited.

After each academic year, it is imperative for the faculty along with their constituencies to assess whether program outcomes are being achieved (Fig. 1, #8) and then use the assessment data to make calculated changes to improve the achievement levels of program outcomes (Fig. 1, #9). Also, faculty must coordinate all significant changes to ensure that the integrity of the curriculum is not compromised (Fig. 1, #10).

Numbers 6 through 10 in Figure 1 need to be completed at least once every academic year if not every semester. Needless to say, this is not an easy job and it requires the full involvement of all the faculty. Even so, the entire continuous improvement system is still not complete. At least once every two to four years it will be necessary for the faculty along with their constituencies to once again assess the achievement of program educational objectives (Fig. 1, #11) and to use the assessment data to make calculated changes to improve the achievement levels of program educational objectives (Fig. 1, #12). At this point it is time to again identify and assess the satisfaction level of the program constituencies' relevant needs and, based on those needs, revisit the hierarchy of development processes beginning with the program educational objectives. Program improvements incorporated as a result of the assessment and improvement processes will probably necessitate the coordinated refinement/reform of the published program educational objectives, program outcomes, program curriculum and/or course learning objectives.

If done correctly, reiterating this system of processes will lead to continuous program improvements and more importantly, to continuous improvements in the quality of the program's graduates.

IV. Continuous Improvement in the Classroom

EC 2000 requires an engineering program to demonstrate that program educational objectives and program outcomes are being measured, and to show that the results of these measurements are being applied to further develop and improve the program's effectiveness. In other words, ABET is looking for continuous program improvement. However, improvements at the educational objectives level and program outcomes level cannot occur without first making improvements at the curriculum level and learning objectives level. In essence, there is a hierarchy in which the sum of the achievement of the learning objectives for all the courses in

the curriculum equals the achievement of the program outcomes, and the sum of the achievement of all the program outcomes equals the achievement of the program educational objectives.

The content of a single course usually addresses several learning objectives. The students and the professor must share the responsibility for achieving these objectives (even though in the past it was sometimes thought that this responsibility rested almost entirely with the students). Accordingly, professors must develop and publish a detailed syllabus that lists and explains the course learning objectives. In addition, professors must develop improved teaching and evaluation methods and materials that will better help their students to achieve the course learning objectives. Course learning objectives do not have to encompass every detail that students may learn. Learning objectives should, however, be viewed as the most important knowledge and skills a course delivers to the students and, therefore, course content, examinations, projects, etc., should be clearly related to the course learning objectives.

Quality improvement at the individual course level requires professors to systematically accumulate relevant data about individual student performance. When individual student performance is not up to par, it is difficult at times to determine whether the problem is with the student, the teacher, the performance standards, or the learning objectives themselves. Therefore, a thorough analysis of the data is necessary for educators to accurately identify changes that will improve student performance. For example, if students are not achieving the desired performance levels relative to a learning objective, then perhaps the performance standards for that learning objective are set unrealistically high, or maybe the prerequisites for that course need to be changed. When the same course is taught by different professors, an analysis of the data may show variations in student performance from one professor to another. In this case, faculty members with student performance below the average may need to re-examine their course design including their teaching and evaluation methods and materials. Again, a careful analysis of the data is required to make accurate decisions.

V. Lessons Learned

The engineering faculty at Loyola Marymount University started to address the issues outlined in EC 2000 beginning in the summer of 1996. Since then, several working retreats have been held with the engineering department chairs, the associate dean of engineering and the dean of the college. In addition, the engineering department chairs have conducted working retreats with their respective faculties. During the past two years, several lessons have been learned from our experiences with implementing EC 2000.

First, it is important to understand that ABET does not specifically state how programs and institutions are to go about meeting the new engineering accreditation criteria, EC 2000. ABET has purposely left it very vague. Basically, ABET is saying to the programs and institutions, tell us what your educational objectives and program outcomes are, prove to us that you are achieving these objectives and outcomes, and show us your feedback mechanism for making improvements. Lesson #1, don’t expect to go to the criteria and have everything spelled out, step-by-step.

Second, it is important to realize that there is no one model or plan to be followed to implement EC 2000. As stated above, ABET purposely left the criteria very vague. Lesson #2, it is

imperative that engineering program administrators and, more importantly, faculty carefully read the new criteria and create their own system of processes for the development, assessment and improvement of their programs.

Third, it is important to realize that the new criteria require the involvement of the entire faculty. In the past, it was possible to meet the accreditation criteria by having the program administrators write much of the self-study reports with minimal input from the faculty. This is not the case with the new criteria. Lesson #3, it is imperative to engage all of the faculty in continuous participation in the development, assessment and improvement processes.

Fourth, it is necessary to start as early as possible. Preparations for the first accreditation visit under EC 2000 must begin, at the very minimum, three years before the visit. It takes a great deal of time to develop objectives and outcomes, to gather enough data to assess whether objectives and outcomes are being met, to incorporate changes for improvement based on assessment data, and to demonstrate the positive results of these changes. Lesson #4, start early.

Fifth, it is absolutely necessary to keep a track record of all meetings and, especially, to document when and how changes for improvement were made and their results. These documents will serve as an indication of the level of involvement of the faculty and the extent to which the processes are in place and integrated into a system for continuous improvement. Lesson #5, document all meetings, changes for improvements and results.

Sixth, although it is recognized that every institution will create its own model for program development, assessment and improvement, it is suggested that each institution adopt one model for all of its engineering programs since some of the assessment processes must take place at the institutional level. Understandably, individual engineering programs within the college will have different ideas on how to develop, assess and improve their programs but one general model should be agreed upon. Lesson #6, each institution should adopt one general model for program development, assessment and improvement.

Seventh, some faculty will be hopeful that EC 2000 will eventually go away and, preferably, before the next accreditation visit. Although modifications to EC 2000 may be made, the core statement will be around for a long time. Lesson #7, EC 2000 is not going to go away. Accept it and institute it as soon as possible. The earlier you start, the easier it will be.

VI. Conclusions

This paper discusses twelve academic processes designed to meet the requirements of EC 2000 Criterion 2 and Criterion 3 and presents a general model established at Loyola Marymount University that integrates those processes into a system for continuous improvement. The model presented can also serve as a framework to help engineering educators and administrators better understand the full implications of EC 2000. This paper also presents some ways in which EC 2000 and its mandate for continuous improvement can be used to increase the quality of teaching and learning at the individual course level. Finally, this paper presents some lessons learned from attempting to implement the new criteria, and offers some suggestions to engineering educators and administrators on how to avoid some of the larger potholes along the road toward compliance with EC 2000.

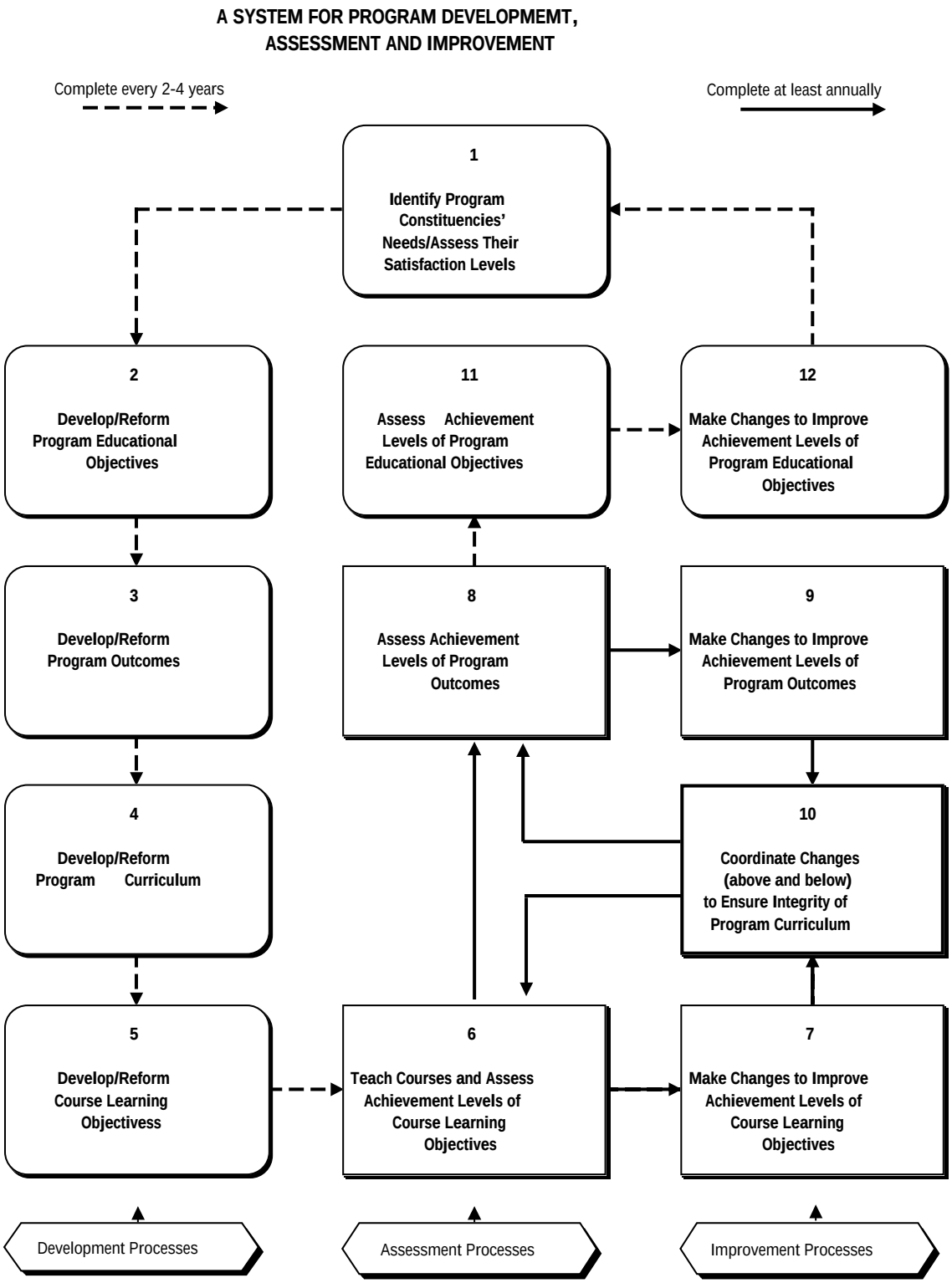

Figure 1. A Process Flow Chart for Program Development, Assessment and Improvement

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