

ABET Criteria 2000: Institutional Preparation and Experience

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***Abstract** - In 1996-97 two universities served as volunteer test sites for evaluation of programs for ABET accreditation under new criteria (Criteria 2000). This paper describes the preparation for the evaluation, and the conduct of the visit for the Electrical Engineering program at Worcester Polytechnic Institute. Criteria 2000 are based on the principles of outcomes assessment and a continuous improvement process relating educational objectives to the curriculum and to educational outcomes. Some lessons learned in this first visit conducted under a set of ABET criteria which are very different from the existing criteria are presented.*

Introduction

The organization which accredits engineering programs in the US (ABET, the Accreditation Board for Engineering and Technology) is in the final stages of approval and implementation of a completely new set of accreditation criteria, called Criteria 2000. These criteria are based on outcomes assessment and an institutional evaluation and improvement process which establishes desired educational outcomes, measures the actual results, and modifies the educational process as appropriate. In 1996-97 two universities served as volunteer test sites for evaluation of programs under these new criteria. This paper describes the preparation for the evaluation, and the conduct of the visit, from the point of view of one of the institutions and programs (Electrical Engineering at WPI) evaluated.

It is expected that the basic structure of ABET evaluations under Criteria 2000 will remain as at present: preparation by the institution of a self-study and data sent well in advance of the visit, followed by a visit of approximately two days duration, with one visitor per program. Given the basic difference in philosophy between the current curriculum-oriented criteria and the new outcome- and process-oriented criteria, substantial differences in both the documentation and visit components are expected to be needed. Examples of these differences, and possible formats for the new documentation and visits, are presented here. These include examples of process and outcomes assessment plans.

WPI, founded in 1865, is the third oldest private university of science and engineering in the U.S. The undergraduate student body size is approximately 2,600 (all full-time students), with approximately 700 M.S. and Ph.D. students. The ECE department includes 21 full-time faculty, and annually graduates approximately 100 B.S., 35 M.S., and 4 Ph.D. students.

It should be noted that the contents of this paper represent solely the views of the author, and not necessarily those of either ABET or WPI.

Summary of ABET Criteria 2000

The ABET Criteria 2000 document will not be repeated here. It is widely available [1]. The eight individual criteria will be summarized:

1. Students: quality, academic advising, evaluation.
 2. Program Educational Objectives: Detailed and published, consistent with the curriculum.
 3. Program Outcomes and Assessment: used to document student performance and improve the program.
 4. Professional Component: This criterion contains several specific aspects:
 - e) Must prepare students for engineering practice,
 - f) Must culminate in a major design experience including **most** of the following: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political aspects,
 - g) One year of mathematics and basic sciences (with experimental component),
 - h) One and one half years of engineering topics, including engineering sciences and engineering design,
 - i) An appropriate general education component.
 10. Faculty: Qualifications and size of the faculty.
 11. Facilities: Appropriate for program objectives, including computation.
 12. Institutional support and financial resources: Adequate for program quality and continuity.
 13. Program Criteria: Organizations responsible for each accredited program are preparing new program criteria.
- Criteria 2000 imply the following system within the institution and within each accredited program:
- A process for establishment of specific educational objectives for the program, involving all appropriate groups (these objectives must obviously be in agreement with the ABET criteria),
 - Clear, published statements of those objectives,
 - An educational system which implements the objectives,
 - An ongoing system of evaluation for each of the objectives,
 - A system for review of the evaluation results and their use to improve the performance of the curriculum against the objectives.

Implications of Criteria 2000

It is widely understood that the present ABET criteria represent a set of minimal acceptable standards which every

student must meet (the so-called "weakest link" philosophy). By the very nature of Criteria 2000, it would be essentially impossible to test every student against every criterion with a definitive standard of acceptable performance in each case. This represents a fundamental change in ABET accreditation approach. Further, measurements for many of the aspects of Criteria 2000 are more complex and more difficult than for the existing criteria. This is true both because some of the items are difficult to quantify (such as the ability to function on multidisciplinary teams) and because some of the desired outcomes result from the integration of multiple educational experiences. Conversely, under the present criteria much of the needed data results from the existing course registration and grading system.

It is not an exaggeration to say that a direct addition of Criteria 2000 to the existing educational system would require the creation of a major new evaluation and record-keeping structure. This would be quite different from, but analogous to, the present system of course credits, exams, and the function of the Registrar's office. An alternative approach would be to fundamentally modify the educational environment to replace some of the existing structure with an outcomes-based evaluation and credentialing system.

WPI has had considerable experience with one form of such a system, which essentially addressed the Professional component of Criteria 2000. This was the "Competency Examination," and required all students to complete a four-day intensive, written and oral exam, generally consisting of a substantial engineering design problem, before a board of faculty. The exam was eliminated for two primary reasons: it could not reliably demonstrate (in four days) the results of a four-year education; and it did not sufficiently motivate students to proper educational activities. Less formally, students who were weak in an area would "take another shot at the Comp Exam" rather than engage in a formal remedial program. With a sufficient number of tries (the exam could be taken as often as four times per year) students would find a good enough match between the specific problem and their specific strengths, to pass.

Outcomes assessment can serve two very different purposes, and a given approach may not be able to serve both. One purpose is to verify the performance of each specific student completing the assessment. The other is to provide evaluative feedback to the faculty on the overall student body performance on that aspect. WPI's competency exam was intended to serve the first goal, and problems became evident. It did, however, provide much useful (and sometimes sobering) data with regard to student retention of knowledge and skills from courses. A key to the implementation of Criteria 2000 may be an understanding of how and where to apply a variety of assessment tools (certainly including exams in courses) to both certify each student for graduation and to provide valuable feedback for program improvement.

It should be noted that Criteria 2000 are not completely outcomes-based. Criterion 4, Professional Component, contains a subset of the present required curricular components, including requirements on math and basic

sciences, engineering topics, and a general education component.

WPI's Educational Program

For more than 25 years, WPI's educational system ("the WPI Plan") has emphasized many of the aspects which appear in Criteria 2000 [2]. It includes a set of Distribution Requirements unique to each major, and a common set of Degree Requirements. These degree requirements are simple to state, and significant in their implications: (1) a "Major Qualifying Project" (capstone design in the case of EE); (2) an "Interactive Qualifying Project" which relates the major to one or more areas of the humanities and social sciences; (3) a "Sufficiency" project in some area of the humanities; (4) an experience in the social sciences; and (5) a physical education component.

All WPI students complete three projects. The Major Qualifying Project challenges students to solve problems typical of those to be encountered in their professional discipline. The Interactive Qualifying Project (or IQP) presents an issue at the intersection of science, technology, and culture, and emphasizes the need to learn about how technology affects societal values and structures. Finally, students complete a Humanities (Sufficiency) project on a theme emerging from a five-course, self-selected series of courses in the humanities or arts, thus insuring that WPI students develop an understanding of the humanities as well as of technology. Taken together, the three projects emphasize that technological professionals must learn not only to create technology, but also to assess and manage the social and human consequences of that technology.

Following is the statement of the goals of WPI's undergraduate program, as adopted by the faculty [2]:

The goals of the undergraduate program are to lead students to develop an excellent grasp of fundamental concepts in their principal areas of study; to gain a mature understanding of themselves; and, most importantly, to form a deep appreciation of the interrelationships among basic knowledge, technological advance, and human need. These principles are today manifest in the WPI Plan, a unique, project-oriented program which emphasizes intensive learning experiences and direct application of knowledge. WPI remains committed to continued educational improvement and innovation.

The objectives of the WPI Electrical Engineering Program are stated below:

The electrical and computer engineering department educates future leaders of the electrical engineering profession, with a program characterized by curricular flexibility, student project work, and active involvement of students in their learning. A balanced, integrated curriculum provides an EE education which is strong both in the fundamentals and in state-of-the-art knowledge, appropriate for immediate professional practice as well as graduate study and lifelong learning. The EE curriculum embraces WPI's philosophy of education, and takes advantage of key components such

as the Interactive Qualifying Project to develop electrical engineers who possess the ability to communicate, work in teams, and understand the broad implications of their work.

The Distribution Requirements address the Professional Component of Criteria 2000, and specify the required number of courses in: (1) mathematics, (2) physics and chemistry, (3) engineering science outside EE, (4) computer science, and (5) electrical engineering. The specific requirements contain essentially no required courses, with all courses being "electives" within broad categories.

WPI has a tradition of strong faculty governance with responsibility for designing and implementing a system which accomplishes the desired educational goals. This can form a link in the feedback process specified in Criteria 2000, but assessment measures must also be in place.

Some aspects of outcomes assessment have been incorporated into the WPI Plan. Both qualifying projects end with major, written reports, and in most cases, with formal, public, oral reports. Further, both project programs are subject to biennial peer reviews by faculty, wherein the reports are reviewed against desired educational components by faculty other than the project advisors. However, a system is not in place to independently evaluate student performance in all its dimensions, outside of the traditional grading system.

We believe that WPI's educational system is well constructed to provide an education leading to the desired educational outcomes as listed in Criteria 2000. This is a good beginning, but this in itself does not constitute a system of outcomes verification and assessment.

Preparation of the C-2000 Self Study

Much of the preparation of the self-study documentation paralleled that for previous ABET visits; however several additional components were added, including:

- Institutional and departmental review of all current and recent assessment activities. These activities include:
 - Biennial comprehensive reviews of Interactive Qualifying Projects and Major Qualifying Projects. This involves a committee review of all projects of the past academic year, evaluating them against the educational objectives, and resulting in a written report recommending procedural changes with respect to any weaknesses.
 - Alumni surveys conducted approximately every five years.
 - Senior exit surveys conducted annually.
 - Input from the ECE External Advisory Committee (with corporate and academic members).
 - Longitudinal assessments associated with curriculum revisions.
- Preparation of a matrix relating our educational activities (projects and courses) to the ABET criteria. This matrix identifies those components of the WPI curriculum where students would be expected to acquire the knowledge or skills referred to in the ABET criteria. All of the criteria were found to be addressed by at least one curricular

component. However, it must be noted that Criteria 2000 are framed in terms of verification of student outcomes, not mere exposure to the material. In some cases it is clear that the normal assessment means (exams, grades, etc.) provide evidence of achievement, but in other cases (such as "lifelong learning") this is not the case.

- Portfolios prepared by students. The traditional physical outcomes of a college education are two pieces of paper: a diploma and a transcript. Particularly in engineering, which is focused on creating things, it seems reasonable that the students conclude their educations with a collection of accomplishments in a literal or figurative portfolio. This would provide direct evidence of some of the desired outcomes. Another benefit is that the assembly of this portfolio over four years necessarily involves the student as an active participant in his/her education. However, as with many assessment-related activities, a way must be found to integrate this into the curriculum, so that student take it seriously, and also to avoid subjecting the students to unreasonable "double jeopardy" where first they must pass via the traditional assessment measures, and then by outcomes-based measures.

- Review of our processes with respect to curriculum review and revision. The departmental and university organizational structure for proposal, deliberation, approval, and implementation of curricular components was described. As at most schools, this involves a combination of departmental and university faculty committees, and administrative offices; fortunately WPI's small size makes the process reasonably efficient. A critical aspect is the provision of data demonstrating how the system actually functions, particularly with respect to ABET's desire for a closed-loop system which measures educational outcomes and feeds back the results through the bureaucracy to effect changes in the educational program. The student follows a direct path through the system, engaging in educational activities and completing related assessments (at present mostly traditional in style, such as exams, reports, etc.). In parallel there is a data collection system and long-term assessment system which measures many of the output variables, which are used by faculty and administration to modify the curriculum. Some of these activities are listed above.

- Implementation of new assessment measures. There is extensive literature in the area of educational assessment, much of which is certainly relevant to engineering education. It is important to take advantage of previous work in this area, both to save time and to increase the likelihood of meaningful assessment results. One useful resource is *Stepping Ahead, An Assessment Plan Development Guide* [3] which was prepared with ABET Criteria 2000 in mind.

Preparation for the Visit

After completion of the Self-Study, much of the visit preparation was essentially identical to the past, since all of the past visit activities (faculty, support programs, computer facilities, administration, laboratory and other facilities,

students) remain central to Criteria 2000. The following items and activities were collected/scheduled:

- Typical course materials (as in the existing criteria),
- Student project reports, together with faculty evaluations of the educational outcomes,
- Reports of outcomes assessments, surveys, as listed in the previous section,
- Student portfolios (collected on a volunteer basis from a small group of students for this initial C-2000 visit),
- Videotapes of a sample of student presentations of their senior projects.
- Time with the ECE curriculum committee and similar groups (critical to the new criteria since these faculty committees "own" the process for evaluating and changing the undergraduate program),
- Time with students, alumni, and employers, primarily to enable the evaluators to collect first-hand data on educational outcomes as viewed by these groups of people.

Conclusions and Lessons Learned

It would be inappropriate to report the specific activities and statements of the ABET visitors for two reasons: (1) the need to maintain the confidentiality and due process of each institutional evaluation and report, which is ongoing as this paper is written; and (2) the fact that in this first experimental visit, an individual action or statement may have no relevance to future visits. Even with these guidelines, it is possible to draw some conclusions from the experience gained in the overall process:

- The move away from the "weakest link" philosophy is necessary given the nature of the new criteria, but leaves several questions unanswered, including the inevitable "how much is enough," as well as the question of whether **any** of the new criteria may be expected to be satisfied by **every** graduate.
- A significantly larger number of specific program aspects are listed in Criteria 2000 than in the present criteria. (The reason that the present criteria document is so lengthy is not that the criteria are more numerous than in Criteria 2000, but because of the apparent need to precisely specify what is intended by each criterion). If this is to be avoided with Criteria 2000, then a very different evaluation philosophy is needed.
- Criteria 2000 touch on more areas of engineering education than the present criteria, and are more broadly based, from the viewpoints of students, faculty, and administration.
- Measurements for many of the aspects of Criteria 2000 are more complex and more difficult than for the existing criteria (i.e. gathering data on course registration is easier than documenting student educational outcomes).
- Clear, specific educational objectives should be in place for the program, and all constituencies (faculty, students, employers) should understand them, and understand how they were arrived at, and how they are periodically evaluated and modified.

- It is important to recognize that an approach to implementation of Criteria 2000 may imply some substantial changes to the academic program, rather than merely an addition of some new procedures on top of the existing program. For example, the replacement of some existing assessments (such as exams) with portfolios or integrative reports, could be considered.

In conclusion, the overall experience as one of the first two pilot schools for Criteria 2000 was quite positive. Further, it is important to take note of, and take advantage of, the greatly enhanced curricular flexibility provided by Criteria 2000.

References

- [1] *ABET Criteria 2000*, Accreditation Board for Engineering and Technology, Baltimore, MD, <http://www.abet.ba.md.gov>.
- [2] WPI Undergraduate Catalog, 1996-97, WPI, Worcester, MA.
- [3] Rogers, Gloria M., Jean K. Sando, *Stepping Ahead: An Assessment Plan Development Guide*, Rose-Hulman Institute of Technology, Terre Haute, IN, 1996.