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Chapter 24

ABET's Engineering Criteria 2000: Our Efforts in a Nutshell

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Ever since the approval of the new Accreditation Board for Engineering and Technology (ABET) Engineering Criteria (EC 2000) by the Board of Directors of ABET on November 2, 1996, and its mandatory application as of Fall 2001, educational institutions across the United States have had to assess and evaluate their undergraduate engineering programs from a different perspective. That is because ABET EC 2000 has been designed to employ the philosophy and practice of continuous quality improvement to engineering programs. Engineering Criteria 2000 calls for each engineering program to identify its constituencies and, based upon their feedback, to formulate the services that each program will provide. The first step is the development of program educational objectives – statements describing expected achievements of graduates in the early years of their careers after graduation as a result of their educational preparation. Usually, educational objectives are expectations of graduates' performance after they have left the school and been in the workforce for three to five years. Subsequently, the second step requires the more specific definition of program outcomes – skills, knowledge and behavior that would be expected of students at the time of their graduation. All this requires considerable time and effort, not only to clearly define the program educational objectives and program outcomes, but also to develop proper and continuous assessment methods and tools, the documentation, the processes, and the necessary culture and philosophy changes that would be introduced as a consequence of the cyclical processes. We, at the University of Puerto Rico at Mayaguez, recognized the significance of EC 2000 early on and undertook planning and organizational steps fully four years prior to the actual site visit. All six of our undergraduate programs were evaluated during November 2002.

OBJECTIVE

This paper outlines the planning and implementation processes/steps that we undertook to educate the general populace, the industry-sponsored EC 2000 mock visits we conducted, and the processes and respective offices with dedicated staff and working committees we established in order to not only prepare for the ABET EC 2000 site visit, but also to develop an organizational structure which will sustain the process beyond the EC 2000 site visit for continuous quality enhancement. Furthermore, the intent of this paper is to share the experience with other institutions that may also be in the early stages of preparation. Various other independent accounts of such experiences can also be found in literature, such as the Ohio State University [1] and Drexel University [2] experiences.

INTRODUCTION

The University of Puerto Rico at Mayaguez (UPRM) is one of the 11 campuses of the University of Puerto Rico System. The UPR System is a public institution, which was created by the Puerto Rico Legislative Assembly on March 12, 1903. It collectively enrolls about 67,000 students. The Mayaguez Campus (UPRM) is a land grant institution that began in 1911 with the College of Agricultural Sciences. Subsequently, other colleges were added as follows: College of Engineering (1913), College of Arts & Sciences (1943), and the College of Business (1970).

The student body consists of about 11,000 undergraduate and 970 graduate students. The College of Engineering has an undergraduate enrollment of 4458 students, of which 36 percent are females, which is one of the highest in engineering among U.S. institutions. This enrollment resulted in UPRM ranking 15th nationally in terms of the number of bachelors' degrees awarded (695) during 2000-2001 [3].

The strategic plan of the College of Engineering was approved by its faculty on October 13, 1998. The vision and mission statements, which are an integral part of the strategic plan, are well in consonance and they subscribe to preparing the "best professionals in engineering" and providing a "strong education in engineering." This commitment to excellence is reflected in the philosophy of our college "to provide a firm educational foundation [4]." Undergraduate education is our strength. While emphasis on research and graduate education with newer doctoral programs is gaining increased attention, the fact remains that graduate degrees have consistently accounted for less than ten percent of the total number of degrees conferred.

The College of Engineering comprises six academic units or departments, which are: Electrical & Computer Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Civil Engineering & Surveying, and General Engineering. These departments collectively offer seven bachelor's degree programs, of which six are in engineering with a separate program in surveying. All of the six bachelor's degree programs in Electrical, Computer, Mechanical, Industrial, Civil, and Chemical Engineering are accredited by the Accreditation Board for Engineering and Technology (ABET).

The bachelor's degree programs at UPRM are of five-year duration as opposed to four years at most U.S. institutions. This provides both breadth and depth, along with ample opportunities for summer internships, undergraduate research, exchange programs, and a strong cooperative education program in partnership with industry. Approximately 27 percent of all undergraduate engineering students avail themselves of this cooperative

education industry experience with the bulk of the students, about 45 percent, coming from the Mechanical and Chemical Engineering programs. The programs underwent a re-accreditation site visit during November 2002 as per ABET's new Engineering Criteria 2000.

Focus of ABET's EC 2000

ABET's periodic review of engineering programs is well accepted as a form of program assessment and quality assurance. Since its enactment, Engineering Criteria 2000 have been well publicized in various sources and, effective Fall 2001, all programs up for accreditation review are being evaluated for compliance against these criteria. These essentially consist of eight criteria with a goal of continuous program improvement as opposed to the earlier focus on rigid quantitative inputs [5]. These criteria encompass: (1) Students, (2) Program Educational Objectives, (3) Program Outcomes and Assessment, (4) Professional Component, (5) Faculty, (6) Facilities, (7) Institutional Support and Financial Resources, and (8) Specific Program Criteria.

George D. Peterson, ABET's Executive Director, states that at the core of these criteria "is an outcomes assessment component that requires each engineering program seeking accreditation or re-accreditation to establish its own internal assessment process, which in turn, will be assessed by ABET [6]." M. Dayne Aldridge and Larry D. Benefield point out that it is not sufficient to merely demonstrate the achievement of educational objectives (Criterion 2) and program outcomes (Criterion 3), but additionally, "a commitment to continuous improvement and the stability to continue its achievement record over the next six years [7]. Frank G. Splitt succinctly remarked, "Engineering education reform presents a formidable challenge, given academe's interest in preservation of the status quo [8]."

The entire review process can be summarized into the following key steps [9]:

a. The Institution requests an evaluation visit.
b. The Engineering Accreditation Commission selects the Team Chair.
c. The Team Chair contacts the Dean of Engineering to select dates for the campus visit, and to determine the status of self-study materials.
d. The Institution provides all applicable Program Self-Study reports to ABET Headquarters.
e. The Team Chair assembles a team by selecting Program Evaluators.
f. The Institution provides all applicable Program Self-Study reports and other applicable materials to the Team Chair, the Program Evaluators, and the Headquarters.
g. The Team visits the campus.
h. The Team conducts an exit interview with university officials and issues a draft statement at the time of departure.
i. The Engineering Accreditation Commission revises the draft statement, if necessary, and takes final action.

Our Early Efforts & Challenges

The leadership of the College of Engineering recognized the importance of EC 2000 as far back as November 1998, fully four years ahead of ABET's next review visit. The upcoming review would be unlike earlier traditional accreditation-related efforts, where

the crux of the effort was put into producing a self-study document and demonstrating that the minimum curricular requirements were met or exceeded. Preparation could not be relegated to the last minute. It was a whole new approach that required early action and planning, and with which few of us were well conversant.

The administrative leadership of the College encouraged a team consisting of department heads to participate in the 2nd Working Symposium on Best Assessment Processes in Engineering Education at the Rose Hulman Institute of Technology in Terre Haute, Indiana. This was the start of our efforts, which was soon followed by the formal establishment of a Faculty ABET Committee with a lead coordinator within the College of Engineering. As John W. Meredith corroborated much later, "The most important element in conducting a successful EC 2000 implementation is commitment at the highest level [10]." Some of the early challenges we faced were: simply getting to understand and digest the implications of EC 2000; team composition and stability; the holding of regular meetings to identify constituents; and discussion and decision on possible assessment methods and tools.

It was quite evident early on that Criterion 2 and Criterion 3 in particular would be the most demanding. Criterion 2 calls for a clear establishment of Program Educational Objectives, with input from the key stakeholders or constituents. An assessment mechanism is required as an embedded self-improvement process (the first loop) for the program educational objectives.

Criterion 3 calls for the definition of Program Outcomes that should, as a minimum, embrace the eleven (a-k) outcomes listed under the criterion, along with proper assessment methods, which would constitute the second loop of the self-improvement process. Criterion 3 could be viewed as a subset that had to map on to Criterion 2, which, up the ladder, was also required to satisfy the mission and vision of the College of Engineering, and eventually, that of the institution as a whole.

Course syllabi were restructured to incorporate applicable (a-k) outcomes. All six programs were required to develop not only their own strategic plans but also, within these, their specific program educational objectives with input from their constituents, and program outcomes. Consequently, this led to the establishment of each program's ABET sub-committee and the scheduling of numerous working retreats by each department. Each department chose its coordinator, who in turn, became member of the Faculty ABET Committee at the college level. Some of the committee members also participated at different stages in the ABET Program Evaluator Training workshops.

Assessment Methods & Tools

Given the new accreditation paradigm that every engineering program establish an assessment process and document results, George D. Peterson was quite correct in his statement "No one expects that the outcomes assessment component of Engineering Criteria 2000 will be easy to implement. Establishing measurable objectives and evaluating their outcomes are sophisticated activities with which most engineering educators have had little or no experience [6]." Thomas Angelo, former director of the Assessment Forum of the American Association of Higher Education (AAHE), defines assessment as "an ongoing process aimed at understanding and improving student learning [6]." An analogy to this departure from the so called "comfort zone" was provided by Lyle Feisel, past president of ASEE, who compared it to the five stages of

grief in Elizabeth Kubler-Ross' book entitled *On Death and Dying* [11]. These five stages were identified as: denial, anger, bargaining, depression, and acceptance.

The Faculty ABET Committee organized a series of one-day workshops in mid-year 2001 that led to the development of assessment tools and strategies package. This was adopted for common use by all programs with each one at liberty to modify or be selective about the recommended methods or tools. The package contained an outcomes assessment matrix, an assessment strategies matrix, and various custom-designed assessment forms for integrating ethics, oral and written reports, teamwork, peer evaluation, course/project evaluations, exit survey, alumni survey, employer survey, and internships. Felder and Brent have also reported on a strategy for integrating program-level and course-level activities to fulfill the ABET criteria [12].

PRINCIPAL DRIVERS FOR CHANGE

Peggy L. Maki, Director of Assessment, AAHE, stated, "All too frequently higher education institutions view the commitment to assessing their students' learning and development as a periodic activity – most often driven by an impending accreditation visit [13]." While this would generally be the case with external drivers such as industry, or ABET, or other institutional accreditors such as the Middle States Commission on Higher Education, we, at the University of Puerto Rico at Mayaguez, had had some experience related to assessment in earlier educational projects, such as MEEP (Manufacturing Engineering Education Partnership) Learning Factory, and PaSCoR (Partnership for Spatial and Computational Research) [14]. Ideally, such should really be the case: universities should be driven by institutional curiosity, an internal motivator, versus attempting to comply, an external motivator [13]. In order to institutionalize this assessment process as part of the various courses, the College of Engineering established a physical office called System for the Evaluation of Education (SEED) in mid-year 2001.

THE SEED OFFICE

With the goal of developing assessing strategies for the undergraduate engineering programs, the principal goals of the SEED office (Figure 1) were to:

- Establish and facilitate a strategy for continuous evaluation of engineering programs and assessment of student learning outcomes.
- Coordinate with engineering departments and accreditation committees (ABET EC2000 and the Middle States Association) the College of Engineering's activities regarding accreditation processes, including their implementation strategies.
- Assess outcomes of the College of Engineering's Strategic Plan.
- Become the College of Engineering's repository of assessment strategies, assessment instruments, and assessment results and reports.
- Coordinate professional development activities concerning evaluation and assessment.
- Disseminate assessment results to stakeholders and decision-makers for their information and decision-making.

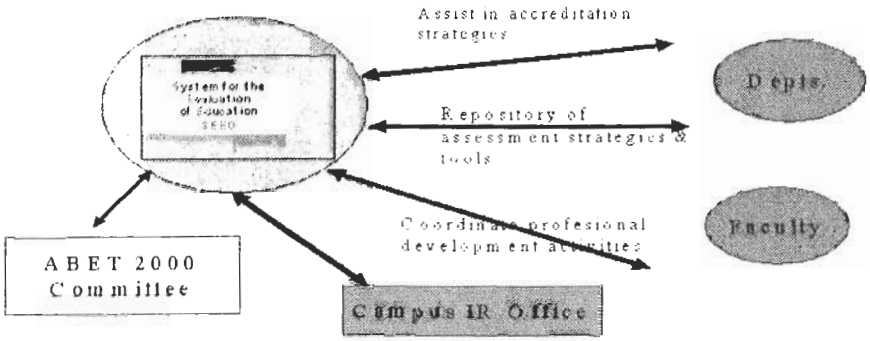

FIGURE 1
SEED OFFICE

The SEED Office counts on the services of a coordinator on a half-time basis, a person in-charge of database management and web page maintenance, and a full-time secretary. As an extension to this concept, similar offices were created in each of the six departments with names such as Continuous Improvement Center, The Curriculum Renewal Plan, and Center for Academic Research.

AWARENESS CAMPAIGN

A series of workshops and retreats were organized, with guidance and support from industry and other U.S. universities, on the definition of outcomes and the development of outcomes-based course syllabi, the development and redefinition of mission statements at individual program as well as faculty level, the mapping of outcomes to program educational objectives, and the implications of ABET's EC 2000 criteria – not only to the faculty and staff in the College of Engineering, but also much later to the faculty and staff of the entire campus as part of a much wider awareness outreach. A number of one-day workshops were also organized on the integration of ethics across the curricula, which were well distributed throughout the period. There were also workshops on assessment and student mentoring which were given by invited faculty members representing the NSF's SUCCEED and Foundation coalitions.

INDUSTRY SUPPORT

Criterion 4 (Professional Component) and Criterion 5 (Faculty) allude to interactions with industrial and professional practitioners as well as employers of students. Robert M. Laurenson from ASME stated, "A positive result of EC 2000 was the involvement of the program Advisory Boards. These groups have provided a very useful resource to the programs in establishing educational objectives and defining associated measurements of student outcomes [15]."

We, at the University of Puerto Rico at Mayaguez, sought out industry partnership very early in the process of preparing for the re-accreditation site visit in November 2002. For example, early in the process, Hewlett Packard donated the server used to collect all

data regarding the College's outcomes assessment and strategic plans. A college-wide ABET EC 2000 Retreat led by Raytheon engineers and quality improvement personnel, and co-sponsored by Microsoft, was organized in November 2000 to assist each program to define their Program Educational Objectives (Criterion 2) and Program Outcomes (Criterion 3). This retreat workshop enabled each program to develop or re-define their mission statement, to develop outcomes-based course syllabi, and to map the outcomes to program educational objectives. This retreat led to an ABET EC 2000 mock visit sponsored by Raytheon Missile Systems, Microsoft, Hewlett Packard and Boeing in January 2002 with team members representing both academia and industry. The objectives of the mock visit were to review the laboratory facilities, conduct interviews with faculty and students, evaluate the first drafts of the individual self-study reports, and to offer candid comments and recommendations to incorporate assessment and continuous quality improvements within the programs.

Early Lessons Learned

The results from the mock visit were an eye-opener for many of us, both the faculty and the administration, and provided vital external feedback on our status. In essence, it provided the impetus towards redesigning the course syllabi, incorporating the applicable outcomes of Criterion (3), and in general becoming more sensitive towards the new criteria. There were severe flaws in the self-study report drafts.

The visit was soon followed by the formation of the first Industrial Advisory Board (IAB) of the College of Engineering in June 2002, although each of the departments had individually been interacting formally or informally with industry representatives. The college saw the need to form the IAB to receive direct feedback from their senior-level industry constituents. Holly correctly pointed out that "EC 2000 has made us much more attentive to the advice and observations of industrial advisory boards [16]."

As an outcome of this IAB meeting, it was recommended that we organize a second ABET mock visit in September 2002, fully two months prior to the actual ABET site visit. The second mock visit team was similarly composed of members representing both academia and industry, like the team in January 2002. The team was provided, prior to their arrival on campus, copies of the final self-study reports for all six programs that would be submitted to ABET by the end of June 2002. This mock visit was sponsored by a much wider group of industries, such as Raytheon Missile Systems, Hamilton Sundstrand, Abbott, Microsoft, Boeing, Merck Sharp & Dohme, and Eli Lilly. During this time, we fared significantly better in all aspects of our preparation, and the mock visit served to provide the confidence for the real evaluation visit in November 2002.

Conclusion

Though the detailed comments with regard to each of the programs are not meant to be publicly listed, all six programs, which were evaluated for the first time as per the new EC 2000 criteria, were accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. However, the comment that "the institution's systematic and innovative effort to introduce the culture of outcomes-based assessment to the College of Engineering community is especially noteworthy" is an indicator of the successful process.

DOCUMENTATION AND CONTINUATION OF ACTIVITIES

Throughout the course of the preparatory efforts during the span of last four years, leading up to the ABET site visit, proper documentation was maintained. This included all reports as well as the minutes of all meetings conducted by the Faculty ABET Team which can be found in the website http://www.abet.uprm.edu. The website can also be accessed from the College of Engineering website http://ing.uprm.edu.

The SEED Office under the College of Engineering is expected to continue providing support to ensure the smooth functioning of similar offices in each department. This will require conducting assessments on a regular basis, utilizing common assessment practices and methods. Mulrine briefly summarizes the various accreditation visit experiences, and at the same time stresses on the need for the post-visit continuous quality improvement phase [17].

In our own particular case, the experience gained from this effort is already being applied towards UPRM's institutional re-accreditation efforts for a decennial visit from the Middle States Commission on Higher Education (MSCHE) in 2005. The new team, using its gathered experience with ABET's EC 2000, has not only formalized some institutional student learning outcomes from the newly-developed plan for the assessment of student learning, but also developed questionnaires for campus-wide surveys with the hope of institutionalizing a continuous improvement process. These efforts are well documented under http://www.uprm.edu/msa.

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