Development and Implementation of an ABET EC2000 Assessment Program: Pros and Cons

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Abstract
Challenges in implementing Engineering Criteria 2000 (EC2000) are addressed in this paper. Steps for establishing an effective assessment program are presented in their context of highlighting the pros and cons of the development process. The assessment matrix introduced in this paper has been applied to a moderate size electrical engineering program. Each of the determined learning outcomes is assessed via multiple tools to improve confidence in assessment findings. Although challenging to develop, the presented assessment program in this paper proved successful in enhancing the assessed educational program.

I. Introduction
The Accreditation Board for Engineering and Technology (ABET) Criteria 2000 emphasizes demonstrating that educational program outcomes have been accomplished and that graduates have attained the desired educational attributes. Of paramount significance is to demonstrate that the mission of the department and its program objectives have been determined based on input from the department's constituencies. Multiple assessment instruments for each objective/ outcome must be determined and data gathering tools should provide sufficient information to support quantitative and qualitative analysis. An ongoing assessment program is expected to be in place such that the recommendations and results received from the data analysis can be used to improve the program and to enhance accomplishment of the desired objectives. An explicit plan for maintaining the assessment program must be established to facilitate effective loop closing on the assessment process.

ABET calls for the following eight evaluation criteria:[1] (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) Program Criteria (discipline dependent). The challenge in the new criteria centers around establishing an effective assessment program. Therefore this paper will focus on Criteria 2-4 and 8 which constitute the new assessment initiative. ABET states the following a-k student learning attributes as a minimum for Criterion 3:[1]

(a) Ability to apply knowledge of mathematics, science, and engineering.
(b) Ability to design and conduct experiments, and analyze and interpret data.
(c) Ability to design a system, component, or process to meet desired needs.
(d) Ability to function on multi-disciplinary teams.
(e) Ability to identify, formulate, and solve engineering problems.
(f) Understand professional and ethical responsibilities.

(g) Ability to communicate effectively.
(h) Possess a broad education necessary to understand the impact of engineering solutions in a global and societal context.
(i) Recognize the need for, and is able to engage in life-long learning.
(j) Has knowledge of contemporary issues.
(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Assessment and its relevant instruments in engineering education have been the focus of several published works.[2-5] The reader is encouraged to review the work by Olds and Miller [4] and Rogers and Sando [5] for information about the process of establishing an assessment program.

Effective implementation of EC2000 requires appreciation of the motivation of the criteria. In these early stages of establishing and applying these criteria, it is occasionally necessary to make assumptions and adopt philosophies most appropriate to one's own situation. This notion is supported by the underlying philosophy of developing an assessment program that originates with one's own constituencies. Appropriateness of the educational program's mission, desired learning outcomes, assessment instruments, and evaluation process and standards are all subject to interpretation and personal judgement. The accreditation requirement in its broader sense is to establish acceptable quality measures and demonstrate that students possess desired learning attributes. Continued improvement of the educational program and maintaining competitive engineering education is the ultimate motivation for adopting EC2000.

This paper presents a successful example of an ABET Engineering Criteria 2000 (EC2000) based assessment program. The Electrical Engineering (EE) department at the University of North Dakota (UND) has successfully demonstrated that a practical and effective assessment program is in place. The department has seven full-time faculty members and it enrolls about 175 students. Although the main focus in the paper is on the pros and cons of developing and implementing the assessment program, the full process from establishing the mission of the department to the development of assessment tools and program improvements are addressed. Typical assessment instruments are presented along with a comprehensive outcomes matrix. Throughout the paper, the statements in *italic font* relate directly to the assessment program which has been developed in the EE department at UND.

II. Development Process

Criterion 2 of EC2000 focuses on the process followed by the department to determine the program objectives based on input from the program constituencies who must be clearly identified. The process may include the following steps:

Step 1 Establish the department's mission - The published department mission must be consistent with the college and university missions. The mission statement reflects the main purpose of the department relative to its contributions to the industry, society, and far-reaching graduates' accomplishments. This statement should be detailed enough to state the department's philosophy in teaching, overall curriculum contents, and how the professional component is addressed. The following is the summary mission statement for the EE program at UND: "*The*

mission of the department is to provide students with a strong foundation in the traditional and contemporary areas of electrical engineering. The objective of the undergraduate program is to educate students in science and engineering so that they can conceive and solve technological problems in society. Social and humanistic issues are also emphasized in the general education component of the program to provide breadth in education. The program provides graduates with the knowledge, aptitudes, and attitudes which prepare them for corporate and governmental entry level jobs or to pursue further education at the graduate level."

Step 2 Determine the program objectives - The educational objectives of the program must be clearly stated as specific broad goals to guide the department in fulfilling its mission. These objectives should be realistic and measurable to facilitate further improving the program. The following five objectives were adopted by the EE department at UND: *1. Provide students with a strong foundation in the traditional and contemporary EE areas, 2. Educate students in science and engineering so that they can identify, understand, and solve technological problems in society, 3. Provide students with the knowledge and opportunity which prepare them for practice or to pursue further education, 4. Provide students with breadth of knowledge in social and humanitarian issues, and 5. Maintain a nationally competitive electrical engineering program.*

Step 3 Demonstrate that the curriculum supports program objectives - The department must demonstrate clearly that the curriculum supports the stated objectives. Required and elective course objectives should contribute to the desired objectives in a progressive fashion such that students have the opportunity to effectively develop their educational attributes.

Step 4 Establish a process to monitor effectiveness of the program objectives - A plan must be developed to revisit the mission statement and program objectives to ensure their continued consistency with the present activities of the department. Changing needs of students, shift in demographics, advances in technology, and changes in the department's focus are among the driving factors in this endeavor. All these factors are not of the highly dynamic nature which suggests a maintenance cycle of four to six years.

Criterion 3 addresses the educational outcomes of the academic program and the assessment plan. This criterion calls for satisfying outcomes a-k as a minimum. Additional outcomes should be determined such that program criteria (Criterion 8) and special educational outcomes are met. These outcomes must be directly relevant to program objectives. *Table 1 lists the 11 outcomes identified by the EE program at UND to satisfy criteria 3 and 8.* The following steps provide guidance in developing and implementing the assessment process:

1. Develop assessment instruments - Typical assessment instruments include alumni surveys, student work, student portfolios, and industry surveys. Each outcome must be assessed by more than one instrument for validity. *Table 1 presents the assessment matrix developed by the EE department at UND.*

2. Establish standards - Each instrument requires designing an evaluation form to be filled out

by faculty, students, alumni, or industry representatives. Evaluation standards should be established to facilitate reaching clear conclusions. For the first cycle of assessment, it is difficult to establish meaningful standards due to the lack of a benchmark for reference. This first assessment cycle, however, presents an opportunity for establishing this benchmark. *On a scale of 1 (low) to 5 (high), the EE department at UND considered 3 to be satisfactory for the first assessment cycle.* Although satisfactory, this level may suggest areas for improvement.

3. Analyze data - Data analysis should be quantitative and qualitative. Quantitative analysis demonstrates to what extent the program outcomes have been accomplished. *Table 1 gives a sample qualitative data analysis summary*. Qualitative analysis, on the other hand, provides insight into issues which lend themselves to debate and special considerations. A list of action items may be compiled based on the data analysis. The purpose of the action items is to address areas that need immediate or future attention to ensure continued program improvement. *The last column of Table 1 shows the overall quantitative data summary per outcome for the analyzed data of the EE program at UND.*

4. Establish a maintenance plan - The department should develop a cyclical plan for evaluation. It is desirable to monitor all outcomes on a short term basis. Annual activities must be determined according to a realistic available resources plan. *The following time schedule was adopted by the EE department at UND: Every year - transcripts, FE exam, co-op surveys, and placement data (all outcomes are addressed at least partially); Every other year - journals, portfolios, lab reports, capstone design reports, and oral presentations; Every six years - student course work, alumni surveys, and admission to graduate programs.*

III. Pros

An integral part of assessment programs is to monitor success in achieving outcomes and to facilitate for improvement. This particular feedback process creates an environment of self-motivation and continued success. Therefore, the ultimate motivation in adopting EC2000 should be to build consciousness, accountability, and a desire to improve. The following are some of the prevalent positives of implementing EC2000:

- The criteria are flexible enough to permit creativity. *The college of engineering at UND found EC2000 most suited to assessing a unique distance education delayed video program for industry personnel.*[6] Innovative nontraditional approaches proved to achieve the same outcomes set for the on-campus program.
- Course objectives become well defined and more coherent to ensure providing sufficient opportunities to achieve program outcomes. Consequently, curriculum development becomes more focused and effective. *Four new courses and several course changes took place in the process of implementing CE2000 in the EE department at UND.*
- Encourage creativity in developing educational methodologies to address learning attributes effectively. *The EE faculty at UND have engaged in several of these activities during the process of developing the assessment program.*[7-9] *Moreover, developing the assessment program provided an excellent opportunity for faculty development.*
- Encourage more interaction between constituencies and better understanding of student and industry needs. For example, *the EE department at UND initiated holding regular general*

student-faculty meetings.

- Development of the assessment program facilitates effective interaction and exchange of philosophies among faculty. These dialogs bring faculty views closer and permit establishing a common understanding of relevant issues. A sense of ownership gets established and a better understanding of one's own views usually take place.

VI. Challenges

Although EC2000 proved beneficial to the quality of engineering education, its initial implementation requires a steep learning curve and a sincere commitment to developing a meaningful assessment program. It is the belief of this author that once an effective assessment program is established, its maintenance will be manageable and of continued benefit. Developing a new assessment program must be approached as an open-ended critical thinking project. One or two faculty members at most should take the lead and work closely with the rest of the faculty and other constituencies to ensure a realistic and need related program. The following are some of the challenges to be dealt with during the development and implementation of a new assessment program:

- Sufficient time must be allocated over an extended period of time. *It took the EE department at UND about four years to develop and implement its assessment program. Over 1,000 man-hours were used during the last two years to work directly on the assessment program.*
- Faculty development resources should be allocated to facilitate interaction with peers. *Several of the EE faculty at UND have participated in ABET workshops, pedagogical conferences, and locally organized workshops.*
- It is easy to drift off on a tangent while working on the assessment program. Professors like to philosophize and reaching consensus is occasionally a challenge. Implementing a successful assessment program doesn't necessarily require every faculty member to be a strong advocate of assessment. What is important is for the majority of the faculty to engage in the assessment process and trust that it is a way to improve the quality of the academic program. One has to set realistic expectations and take a practical approach based on moderate goals. *Starting with moderate goals, the EE department at UND was able to demonstrate some progress, then build on it to reach a higher target. The department is fortunate to have a coherent and enthusiastic faculty body.*
- Assessment of soft-skills requires conservative thinking to facilitate a meaningful assessment tool. For example, outcome (i) states "graduates should **have a recognition of the need** for, and **are able to engage** in life-long learning." *To assess this outcome, the EE faculty at UND decided to demonstrate that students have been successfully exposed to activities within their academic program that would enhance their life-long learning skills. Student work demonstrated interest and ability to seek and grasp new knowledge. Critical thinking and open-ended problem solving skills are considered directly relevant to student ability to engage in life-long learning.*
- It is easy to overburden constituencies during the assessment process. For example, students can get tired of filling out survey forms. Also it is a challenge to have industry respond to surveys, not because they don't want to but because the surveys are not clear and data is not readily available.
- It is hard to determine the necessary level of depth in assessment. In these early stages of implementing EC2000 it is hard enough to figure out what needs to be done not to mention

the level of sophistication of the process that should take place. *The EE department at UND took a conservative approach in getting started, then it was able to improvise until a credible process evolved.*

Conclusion

Although demanding on manpower and resources, the assessment program proved successful in contributing directly to enhancing student education and in providing the opportunity for self-assessment and continued improvement. Inclusion of constituencies in the steps of developing and implementing the assessment program created a close community within the department and enhanced communication among concerned entities. Numerous opportunities for curriculum development were identified and creative teaching approaches have emerged.

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Biography

Nagy N. Bengiamin is a professor and chairman of electrical engineering at the University of North Dakota. He received the M.S. in systems engineering from Carleton University in 1974, and the Ph.D. in electrical engineering from The University of Calgary in 1979. His research interests include controls, robotics, and electric power systems operation and control. He has consulted for the electric power and manufacturing industries and has published numerous technical articles on nonlinear control with applications to robot manipulators, fuzzy logic control, electric power distribution and energy management. He is a member of ASEE, IEEE, and Tau Beta Pi.

Table 1 Learning Outcomes Evaluation Matrix

	Trans.	*FE*	*Journal*	*Home-work & exams*	*Lab reports*	*Portfolio*	*Capstone design reports*	*Grad. survey*	*Employer survey*	*Co-op survey*	*Place-ment*	*Video pres.*	*Adm.to grad. prog.*	*Course eval.*	*Average per outcome*
Outcome 1	(1)	(3)	4.0 (2)	4.5 (2)	3.5	4.5	3.2 (1)	3.6 (2)	4.0 (2)	4.0	(2)	4.3	(2)	4.2 (3)	3.9
Outcome 2	(1)	(3)	4.0 (2)	4.1 (2)	2.7		2.3 (3)	(3)	(3)				(2)	4.0 (3)	4.0
Outcome 3	(1)	(1)	3.0 (3)	(2)			1.9 (3)	(2)						3.6 (3)	
Outcome 4	(1)	(3)	3.9 (2)	4.4 (2)	2.1	4.0 (2)	4.2 (1)	3.9 (2)	3.6 (2)	4.0 (2)	(2)	4.3 (3)	(2)	4.1 (2)	4.0
Outcome 5	(2)		2.8 (3)		4.7 (1)	5.0 (2)	4.9 (1)	3.6 (2)	2.0 (2)	4.5 (3)	(3)	4.5 (2)		3.8 (2)	4.1
Outcome 6			3.9 (2)	2.8 (2)	2.6 (3)	4.8 (2)	4.7 (1)	3.8 (2)	3.6 (2)	4.3 (2)		4.4		3.8 (2)	4.0
Outcome 7		(3)	3.7 (2)	3.5 (1)	3.8 (1)	5.0 (2)	4.1 (1)	3.7 (1)	3.1 (1)	(1)	(2)	(3)		3.7 (2)	3.8
Outcome 8			4.2 (1)		2.8 (1)	4.8 (1)	4.3 (1)	3.6 (2)	3.4 (1)	4.2 (1)	(2)	4.3 (1)		3.5 (2)	3.9
Outcome 9			4.3 (2)		3.9 (1)	4.5	4.2 (1)	3.6 (2)	3.4 (2)	4.7 (2)	(2)	(2)		3.5 (2)	3.9
Outcome 10	(1)	(3)	3.2 (2)			3.8	1.6 (3)	3.4 (2)	4.0 (3)	(3)				4.5 (2)	3.7
Outcome 11			2.6 (2)		1.4 (3)	4.7 (2)	1.7 (2)	3.9 (2)	3.2 (2)	4.4 (3)			(2)	4.0 (2)	3.35

The numbers outside parentheses are for assessment data **(5=High and 1=Low)**.

The numbers in parentheses are indicators of the instrument's significance to the specific outcome; **(1)=Strong, (2)= Moderate, (3)=Possible**

Outcome 1 - Breadth in EE subjects and ability to apply knowledge of mathematics, science and engineering (ABET outcomes a and h)
Outcome 2 - Basic science, mathematics, and statistics (Program outcome)
Outcome 3 - Basic understanding of non-EE engineering subjects, applied mathematics and physical science (Program outcome)
Outcome 4 - Depth in EE (ABET outcome e)
Outcome 5 - Hands-on experience (ABET outcome b)
Outcome 6 - Open-ended problem solving (ABET outcomes c and e)
Outcome 7 - Computer skills (ABET outcome k)
Outcome 8 - Communication skills (ABET outcome g)
Outcome 9 - Teamwork (ABET outcome d)
Outcome 10 - General Education Requirements and contemporary issues (Social science, humanities, economics, ethics) (ABET outcomes f, h and j)