Experience with an EC2000 Visit: a view from Michigan Tech's Electrical Engineering Department

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Introduction

It all started on March 11, 1997. The new Dean of Engineering, Bob Warrington, was attending our faculty meeting. In addition to announcing that we had hired a new Dept. Chair, he was promoting the idea that the College of Engineering should be evaluated under the new ABET Engineering Criteria 2000 (EC2000). The Dean had just joined the college the last December. He was an experienced ABET evaluator (the next fall he would be an evaluator for Georgia Tech's pilot EC2000 visit) and could see the advantages of becoming accredited under the new criteria. Our self-study year was to be the 1997-98 academic year and the College needed to apply to ABET to be evaluated under the new criteria by May 1, 1997.

From our department's perspective, the College was in a good position to be evaluated under EC 2000. We had an up-to-date curriculum. We were in the middle of the conversion to a new curriculum, with the first graduates under the new program being in the 1997-98 academic year. We also had an ongoing assessment program. The University was in the middle of the self-study year for the North Central Association (NCA), our regional accreditation agency. Since our last regional accreditation ten years ago, the NCA had embraced a continuous improvement philosophy, and our department was in the process of implementing an assessment plan developed over the past year and a half.

From our perspective it would be easy. We would be able to make small adjustments to our assessment plan developed for the NCA, collect our program information, and sail through the accreditation process with a N.G.R. (next general review).

Euphoria Lost

It turned out to be a much bigger problem than we had initially thought. There are many differences between what NCA wanted and what ABET required. In the assessment programs that the University developed for NCA, the departments were primarily concerned with what students were learning within the given department. For ABET, we needed to look at the whole degree program, both the courses within the major and those in other departments. In addition, ABET had predefined outcomes of the program, whereas for NCA we used self-defined goals and outcomes. Probably the biggest difficulty was that the assessment program we developed for the NCA evaluation was not ingrained within the department. If we were to succeed with the ABET evaluation, this had to change.

Our NCA experience did give us several advantages. To begin with, the NCA made us think about formal assessment. This is not something that most engineering educators naturally do, and it takes time for the concepts to sink in. To help departments with the NCA assessment, the university set up the Assessment Council, a group of departmental representatives who meet to share information and to help oversee the assessment process. The Dean's office took the que from this and set up an analogous group to help with the ABET visit. This was a great help. It got the interested parties together and created a forum in which to struggle through the issues together.

Understanding the EC2000 process

As we got to the work preparing for our self-study, we managed to severely confuse ourselves. Our recent NCA experience not withstanding, we were new at the process of assessment and what little experience we had was not shared widely throughout the department. Probably the most difficult part was getting everyone (or at least a sufficient fraction) in the department to understand the vocabulary so that we could understand what we were reading and so that we could communicate amongst ourselves. For example, there are faculty in our department who even today do not understand the distinction between program objectives and program outcomes. (Program objectives are what you want your program to do; program outcomes are the measurable results of your program.)

Our first look at ABET's "Two Loop" diagram (see Figure 1) of the EC2000 process did not help. The two loops did not seem to adequately describe the process. Where did the faculty fit in? It was full of words such as "constituencies" which we did not understand. Was that the same as customers?

After struggling with the concepts for a few months the fog finally started clearing. I finally began to see the big picture and than the details started to make sense. The aim of the EC2000 criteria is the continual improvement of the education of our students. A secondary aim is to allow our University to tailor our program to fit our circumstances.

With the help of our constituents, we were to define what we wanted our degree program to do. We were to decide what type of graduates we wanted and what they would be able to do. We also had to continually evaluate these objectives and to improve on them. This is the purpose of the small upper left loop of Fig. 1.

The second loop is concerned with the process of doing what we set out to do. Here we need to ask ourselves if we are doing a good job. How do we measure that? We come up with an assessment plan which measures some outcomes. The outcomes are designed so that if our students have those outcomes then our objectives have been meet. We also design an adaptive control system in which we adjust our education program to improve the outcomes, and thus improve on our objectives.

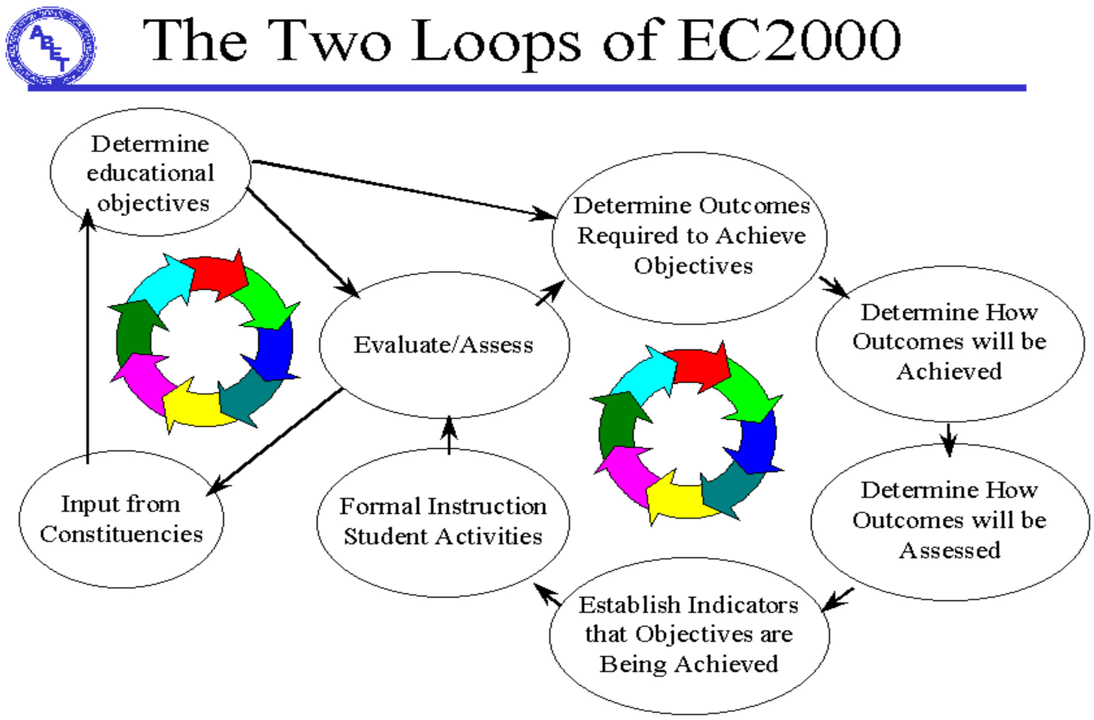

Figure 1: The Two Loops of EC2000 [1]

This is a radical change from the old ABET criteria. In addition to being concerned with a quality education, the EC2000 criteria is concerned with the PROCESS of improvement. The new ABET forms a partnership with the universities in an effort to improve education. This requires not only assessment, but using the results of the assessment to improve the program. The other difference is that EC2000 does not PRESCRIBE what constitutes an engineering program. It relies on the department to make the case that theirs is a good program and then relies on the judgment of the visitor to insure that is so.

Michigan Tech's EE Department's Process

The improvement process that we devised is best summarized in Figure 2. Each box represents an object and the arrows represent actions of the faculty which connect the objects. The outer loop represents communication with our constituents. The inner loops represent development and improvement of the educational program and the assessment program. Much of the processes shown have been going on informally for years. It was our task to formalize the processes and then improve on them.

The outer loop is the slowest, and it is here that the process starts. With input from our constituents the faculty define the program objectives and the resulting outcomes. Form here we define the educational program. Students go through the program and along the way we gather data. The data is collected through our assessment measures and from there the department's assessment committee interprets the findings. At this point three separate paths diverge.

Depending on what is found, the faculty can decide to change the assessment measures (for instance if a particular measure is too time consuming and there is an easier way to measure the same thing), the faculty can decide to change the educational program (for instance if we found that probability and statistics were only used in the required math course), or the faculty can

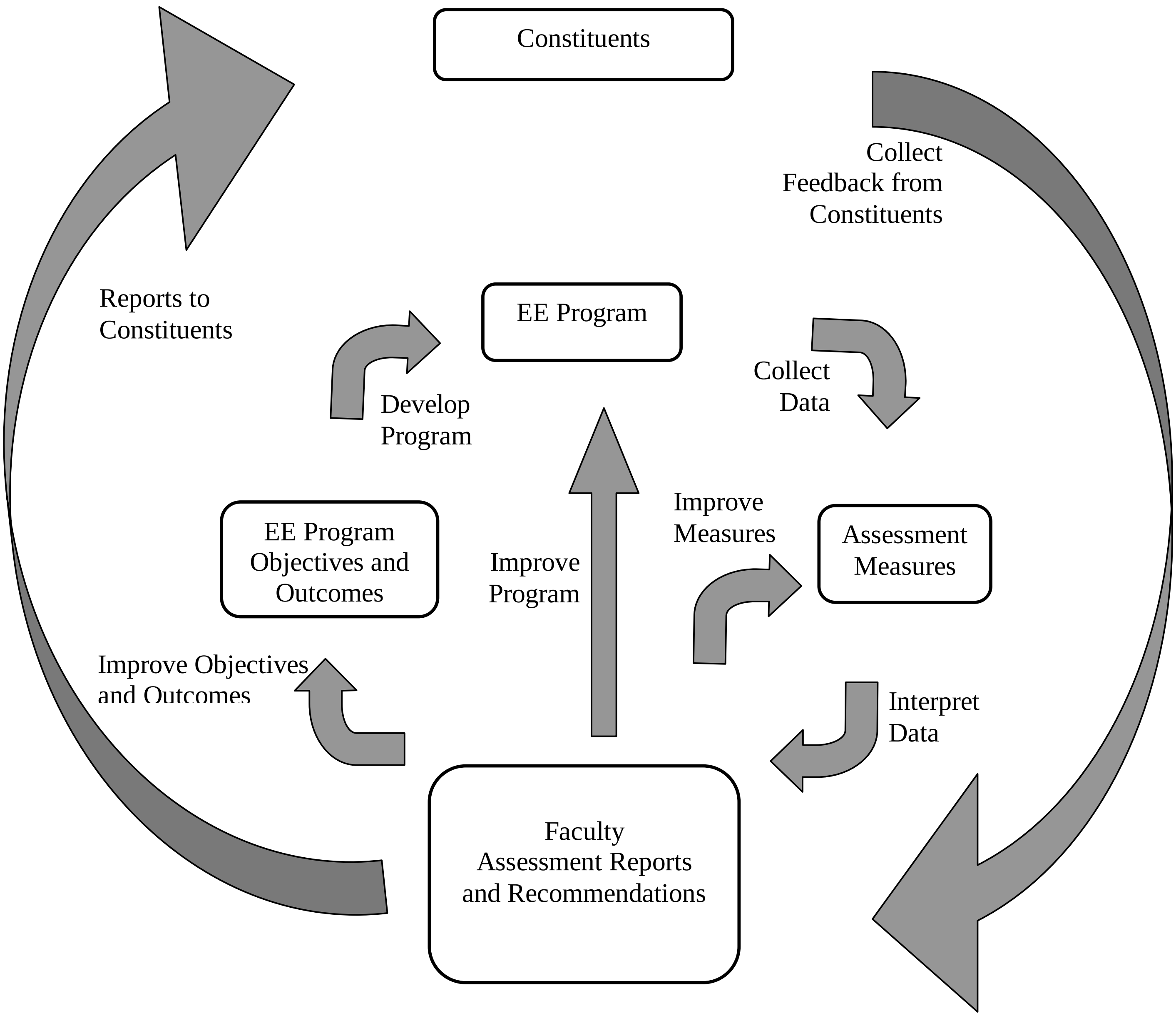

Figure 2: Schematic Illustration of the Assessment Process

decide to change some of the objectives (for instance if we decided that the objectives did not accurately describe what we wanted to). Changes to the assessment program and minor changes to the educational program will happen much more often than changes to the program objectives. To complete the outer loop, the students and the faculty will interact with our constituencies. From that interaction we will solicit and gather feedback so that we can continue the process.

The Details of Our Program

Our first task was to figure out who our constituencies where. According to the Random House dictionary [2], a constituency is any body of supporters, customers, etc., a clientele. After some thought, we defined our program's constituencies as students, employers of our graduates, graduate programs, the faculty, ABET, and parents.

From informal feedback over the years from our constituents, we defined our objectives. They are:

Each electrical engineering student must acquire:

I. A strong knowledge base in mathematics, basic science and engineering science as the foundation for life-long learning.
II. The ability to use this knowledge base, and to apply engineering skills to the creative solution of problems.
III. The ability to communicate effectively.

These are fairly generic objectives, ones which would fit many programs. I envision our objectives evolving into something which will more uniquely define our program.

We felt that our program did not need any initial changes in order to accomplish these objectives. We had just finished a major revision of the curriculum and we felt any needed changes would be minor adjustments that the assessment process would bring to light.

For expediency, we chose to adopt the outcomes listed in the EC2000 criteria as our program's outcomes. They are:

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs
d) an ability to function on multi-disciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
l) knowledge of probability and statistics, including applications appropriate to the program name and objectives
m) knowledge of mathematics through differential and integral calculus, basic sciences, and engineering sciences necessary to analyze and design complex devices and systems containing hardware and software components, as appropriate to program objectives

n) knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics

Again, I envision these outcomes evolving into to something which are more unique to Michigan Tech.

The relationship between the program objectives and the outcomes is summarized in Table 1.

Table 1: Relationship of Program Outcomes to Program Educational Objectives

	Program Outcomes														
Program Educational Objectives		a	b	c	d	e	f	g	h	i	j	k	l	m	n
	I	●	◐	◐	○	◐	○	○	○	●	○	●	●	●	●
	II	●	●	●	◐	●	○	◐	○	●	○	●	◐	●	○
	III	○	○	◐	●	●	◐	●	◐	◐	◐	◐	○	○	○

●	◐	○

The table demonstrates that the students performance in regard to the outcomes listed is directly related to our achievement of the objectives of our educational program.

The next task is to figure out how to measure these outcomes. We came up with 9 assessment tools. They are:

i) Assessment examinations in EE111 and EE211
ii) Assessments of the senior design capstone experience.
iii) Selective assessment using final exam questions.
iv) Sampled retention of expected prerequisite knowledge.
v) Mid-program communication skills assessment.
vi) Survey of department alumni after graduation.
vii) Survey of results of the Fundamentals of Engineering exam.
viii) Assessment by other units of the university.
ix) *Ad hoc* assessments.

Each of these tools are described in detail in our self-study report and our assessment plan, both of which are available from our web page [3]. Of these nine measures, three focus on incrementally achieved outcomes (items 1, 3, and 4, above). Five of the nine are direct assessments (items 1 through 5, above). Each assessment tool measures several of the outcomes and each outcome is measured with multiple tools. Table 2 illustrates the correspondence between our "toolbox" and the program outcomes.

Table 2: Correspondence of Assessment Tools to Program Outcomes.

Program Outcomes → / **Assessment Measures** ↓	(a) knowledge of math science, and engineering	(b) conduct experiments, interpret data	(c) design system, component, or process	(d) function on multi-disciplinary teams	(e) identify, formulate, solve engineering problems	(f) understanding of professional and ethical responsibility	(g) ability to communicate effectively	(h) understanding of global and societal contexts	(i) life-long learning	(j) knowledge of contemporary issues	(k) modern tools necessary for engineering practice	(l) knowledge of probability and statistics	(m) knowledge of differential and integral calculus	(n) knowledge of advanced mathematics
(i) assessment exams	√				√						√	√	√	√
(ii) senior capstone design	√	√	√	√	√	√	√	√	√	√	√	√	√	√
(iii) final exam questions	√	√	√		√		√				√	√	√	√
(iv) expected prerequisite knowledge	√	√	√		√		√				√	√	√	√
(v) communication skills							√	√	√	√				
(vi) alumni survey	√	√	√	√	√	√	√	√	√	√	√	√	√	√
(vii) FE exam	√					√					√	√	√	√
(viii) other university units				√			√	√	√					

Closing the Loops

While the assessment procedures took the most time to develop and implement, they are not the most important part of the process. The focus of the process is the IMPORVMENT of education. Collecting assessment data and then not acting on it is a waste of time. The tabulation and analysis of the assessment data is done initially by the department's assessment committee. The committee's report is given to the faculty. This committee also makes recommendations on the improvement of the assessment program. Using the assessment report, the department's undergraduate program committee is charged with developing specific recommendations for improving the program, by changing the program, changing the program outcomes, or changing the program objectives. Once approved by the faculty, this committee is also responsible for implementing the recommendations.

Closing Remarks

The accreditation process is arduous. It now may seem more arduous given the EC2000 criteria. I believe that this is primarily a function of the step change in the requirements. We are experiencing the overshoot which comes from an underdamped system. Soon the transients will settle and the amount of time needed for accreditation will hopefully be comparable, if not less, than the time spent under the former criteria. In addition, under the new criteria the time spent on accreditation will directly improve the program. We know of no shortcut that will lessen time needed to establish a culture of continuous improvement within an academic department, but the results are worth the spending the time. The effort required for the changes can be eased somewhat by forming a college wide group which meets to share information, to coordinate efforts, and to collectively solve problems.

With EC2000 the focus has shifted to include the process of improvement. The self-study report will have to describe this process. There needs to be sufficient supporting documentation to show that the processes operate as described, that the department's faculty buy into the continuous improvement processes, and that the assessment data is used to improve the processes. It was this documentation that our visitor was most concerned with, and with it we were able to show our efforts in establishing the process. Our visitor was not looking for perfected processes, or, if he was, he certainly did not find them. What we were able to show was that our processes are able to catch our shortcomings, and the next time things will be better.

References

[1] "The Two Loops of EC2000"; Accreditation Board for Engineering and Technology, Inc.; Baltimore, MD ; http://www.abet.org/eac/two_loops.htm
[2] The Random House dictionary of the English Language, Unabridged Edition; Random House; New York; 1996.
[3] "MTU Department of Electrical Engineering"; Michigan Technological University; 1999; http://www.ee.mtu.edu/

Biographical Information

Leonard J. Bohmann is an Associate Professor of Electrical Engineering at Michigan Tech. He earned his MSEE and PhD from the University of Wisconsin-Madison in 1985 and 1989 and a BEE from the University of Dayton in 1983. He is a member of the Electrical Engineering, Energy Conversion and Conservation, and Educational Research and Methods Divisions of ASEE, an active member of IEEE, and a Licensed Professional Engineer in Michigan.

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