ABET Assessment:

Is It Really as Difficult as It Seems?

Dr. Claire L. McCullough, P.E. [1]

Abstract – While EC2000 was developed with the laudable goals of ensuring "*program improvement* and *quality assurance* in higher education" [1], from the point of view of the ABET accreditation visitor and the programs being evaluated, the EC2000 criteria can be both more difficult to understand and more difficult to apply than the more specific and straightforward criteria which they replaced. In addition to the process elements which the EAC has intended to be included as part of the EC2000 evaluation, the difficulties of assessing some of the required a-k criteria, such as "lifelong learning" and "global considerations," as well as the increasingly expected "triangularization" of outcomes, have intimidated evaluators and universities alike. This paper gives commonsense examples in which the requirements can be met by a small program without an undue extra burden on the faculty.

Keywords: ABET, Outcomes Assessment

THE PROBLEM

In the late 1990's, when the Engineering Accreditation Commission (EAC) of ABET transitioned from the previous set of uniform, "one size fits all" accreditation standards to EC2000, one purpose of the change was to allow each engineering program to set its own goals and objectives to better fit the needs of its specific constituencies. Each program was encouraged to identify its relevant constituent groups, collect and use information from these groups to establish mission, objectives, and outcomes for the program, measure and assess success in meeting these goals, and use the data and knowledge acquired for continual improvement of the program. While the changes were made with the laudable goals of ensuring "*program improvement* and *quality assurance* in higher education" [1], from the point of view of the ABET accreditation visitor and the programs being evaluated, the EC2000 criteria can be both more difficult to understand and more difficult to apply than the more specific and straightforward criteria which they replaced. In addition to the process elements which the EAC has intended to be included as part of the EC2000 evaluation, the difficulties of assessing some of the required a-k criteria, such as "lifelong learning" and "global considerations," as well as the increasingly expected, though not officially required, "triangularization" of outcomes (assessing each outcomes by three or more disparate methods), have intimidated evaluators and universities alike. The confusion caused by the lack of specificity in the EC2000 requirements has spawned a myriad of workshops and consulting services of varying quality, offering to help programs navigate the labyrinth. While many of these are useful services, others recommend either "hiring out" the entire process, which not only totally violates the EC2000 goal of increased faculty involvement in the continuous process improvement cycle, but is also beyond the means of many programs at small public or private programs. Yet others recommend assessment processes so complex and burdensome that they cannot reasonably be performed by faculty who have other responsibilities.

In the author's own experiences, both as an ABET accreditation visitor for Electrical Engineering programs since 1992 and in the recent successful initial accreditation of the UTC EE program, simple and straightforward ways in which activities which universities already conduct can be expanded or modified, or activities can be added, to meet the requirements of ABET assessment without adding a large additional burden on faculty, students, or program

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administrators, have been observed. While no one paper of this length can be "Everything Everyone Ever Wanted to Know About ABET Assessment," this paper gives specific examples of ways in which assessment requirements can be met by a small program in a practical, non-burdensome way.

Background on EC2000 Requirements [2]

While it is beyond the scope of this paper to give a complete description of the EC2000 accreditation criteria, some of the key points which distinguish EC2000 from the previous criteria are discussed in this section.

One of the key differences between the current criteria and the earlier versions is that the program to be accredited must show that it not only has a process by which goals and objectives are regularly reviewed and revised, but that the various "constituencies" of the program must be consulted and given a voice in goal setting. Some groups commonly defined as constituencies of engineering programs include students, local industry and other potential employers of program graduates, graduate schools, the community in which the program is based, and faculty of the program.

One area of the new criteria which has proved confusing for many programs is the difference between the "objectives" and "outcomes" which the program must define and demonstrate that students and/or graduates successfully meet. In the 2004-2005 version of the EC2000 criteria, ABET has solidified the definitions which had been widely discussed, but not, until this time, completely documented. The official definitions are "program educational objectives are intended to be statements that describe the expected accomplishments of graduates during the first several years following graduation from the program" and "program outcomes are ... statements that describe what students are expected to know or be able to do by the time of graduation from the program." [2] Both outcomes and objectives must be assessed and success in meeting them demonstrated.

The most commonly discussed aspects of EC2000 are the famous (or infamous) Outcomes a-k, which all graduates of ABET accredited engineering programs are required to meet. These are quoted below from [2]

(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.

Some of these, for example "lifelong learning" and understanding "impact of engineering solutions in a global and societal context," are considerably more difficult to measure than more concrete and traditional criteria such as "ability to design a system...to meet desired needs."

Additional criteria which must be assessed are the "major design experience," commonly called the "capstone" design or course in Criterion 4, and any program specific criteria: for example, for Electrical Engineering programs, specific criteria include "breadth and depth across the range of engineering topics implied by the title of the program... knowledge of probability and statistics...knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives." [2]

The remaining criteria, such as Students, Faculty, Facilities, and Institutional Support, while very significant, are sufficiently similar to the previous criteria that most programs do not seem to have significant difficulty interpreting or evaluating these. However, another *very* significant difference in the criteria is that previously it was considered sufficient by ABET evaluators to demonstrate *what was taught* in courses in the program. Under EC2000, the program must clearly demonstrate that students are not only *taught* the material, but that they *get it!*

A COMMONSENSE SOLUTION

The differences between EC2000 and the previous criteria, and the lack of specificity in some of the criteria, led to a certain amount of panic on the part of programs nearing accreditation visits. Workshops on the new criteria, and consultants offering their services, filled the void with voluminous, sometimes conflicting, advice on how the criteria could be met and demonstrated. What follows is a commonsense approach to assessment, with examples of successful assessment processes that do not place an undue burden on faculty. The key points of this approach are:

- Select outcomes and objectives with assessment in mind;
- Look at what you're already doing;
- Look at what can be added without putting additional burden on the faculty;
- Make everything you do count;
- Look at the big picture.

Take Assessment into Account as Goals, Outcomes, and Objectives Are Set

Many programs have found themselves in the position of trying to back-fit assessment processes to measure success in meeting goals, outcomes, and objectives which have been previously determined. While this can certainly be done, it can also be considerably more difficult than assessing items which were selected with assessment in mind. While some possible objectives and outcomes may sound laudable, they may be almost impossible to assess. For example, "Each student will perform to his or her optimum level" would be an excellent outcome (or objective), but how can "optimal performance" be measured? While your program should select objectives and outcomes which are most responsive to the needs of your constituencies, if they can be re-stated in a more easily measurable format, the assessment can be much less burdensome. For example "Each student will graduate with a thorough understanding of the engineering design process" is considerably harder to assess than "During the course of his or her education, each student will demonstrate an understanding of engineering design by completing X design projects of increasing complexity, and culminating in a major capstone design to be completed during the senior year."

Look at What You're Already Doing

When faculty began the evaluation to determine what assessment means needed to be added to the Electrical Engineering program at the University of Tennessee at Chattanooga, it was first observed that for many years, course folders containing syllabi and examples of student work on assignments and exams had been routinely collected. By adding an evaluation to these course folders, they were easily turned into an acceptable assessment means for ABET outcomes. To each course folder was added an evaluation sheet listing ABET outcomes and other goals of the course. At the end of the semester, the instructor of the course examines the student material in light of the desired outcomes, and determines whether in his or her opinion they were met. He or she also provides information for the other faculty as to where outcomes can be observed; for example, if students conduct experiments in every week of a lab course, but only actually design experiments in labs 2 and 5, this is stated on the evaluation sheet by the course instructor. At the beginning of each semester, the EE faculty routinely hold a meeting to review all of the Electrical Engineering course folders from the previous semester. At this meeting, each course folder is reviewed by two additional EE faculty who both comment on how well the desired outcomes were met and make any comments on how the course could be improved. The additional work required in converting information collected, but not used, to a useful process is estimated at approximately 30 minutes per course for the initial assessment by the course instructor, and a single additional faculty meeting for the peer review.

One program, which is not identified here due to the privacy requirements of ABET evaluation, had required that each student, over the course of his or her academic career, put four design projects into a design portfolio before being approved for graduation. As in the previous example, while data was being collected, no evaluation was

being done, and so the information was not useful as an ABET assessment tool. By adding a layer of assessment to the folders which were already being produced, the student design portfolios could be used for assessment of ABET a, b, c, e, g, and k. The process which was devised simply required the student's advisor to evaluate the portfolio for these criteria before graduation and report any problems to the department chair, who would bring any systemic problems observed back to the faculty for action. The portfolios and the evaluation forms were then to be provided to the ABET visitors as objective evidence that the criteria were being met (as the visitor would be free to evaluate the portfolios to evaluate the design and other criteria himself), and that assessment was being performed.

UTC, like many other universities, requires that faculty and course evaluation be conducted at the end of every course. By adding questions to those existing surveys as to ABET a-k, and other course goals, outcomes, and objectives, information can be easily produced which can be used as an ABET assessment tool. The resulting data can be used either qualitatively or quantitatively to determine areas of a course which should be improved, or ways in which goals can be better met. The only additional requirement in order to use this for outcomes assessment would be that a record be kept of how the information is being used to improve the course. This can either be done by the simple expedient of capturing discussion on these areas in meeting minutes, or, as in the case of a program recently evaluated, keeping of a running file on "Course Evolutions" for each course. Again, the additional work required to turn existing information into a process is minimal.

A routine existing writing assignment can be altered to better assess required elements for ABET. As described in [3], in preparing for the planned ABET visit to the University of Tennessee in Chattanooga in Fall 2003, as part of EE's continuous assessment and improvement processes, the Electrical Engineering Faculty had noted a concern in the area of measuring understanding of professional and ethical responsibility, understanding the impact of engineering in a global and societal context, and knowledge of contemporary issues. While both seniors and alumni were being surveyed and asked how well the program had succeeded in communicating these core values, the faculty could point to no objective, scorable assignments where all of these were addressed. When ENEE 473, "Analog and Digital Communications," had been taught to seniors at UTC prior to 2002, students had been required to write a technical paper, which counted 20% of the total course grade, on one of the issues, techniques, or technologies covered in the course. Beginning in Fall semester 2002, the assignment was stated as follows:

> Identify a way in which a communications technology has impacted society, for better or worse. Discuss both the technical aspects and the societal impact of the technology, and support what you believe to be an ethical engineering response to that issue.

This assignment required both a written paper of 8-10 pages with at least 3 references, and an oral presentation to the class, using appropriate visual aids, which were the same as the requirements of the earlier, solely technical, assignment. Not only have the papers since the assignment change been considerably more interesting and thought provoking than previous versions, but by making the papers available to the ABET accreditation visitor and by adding questions to the existing end-of-course survey regarding how well this assignment had contributed to student understanding of professional and ethical responsibility, understanding the impact of engineering in a global and societal context, and knowledge of contemporary issues, the assignment provided both an objective means (the written papers themselves) and a subjective means (the student responses on the survey) to measure ABET f, h, and j. Similar assignments could be made in many upper level engineering courses, without a significant change in the course flow or paperwork for the professor.

While the previously mentioned examples provide some objective evidence, such as papers or design portfolios, which can be examined by the ABET visitor, an objective measure of student performance compared to other students in similar programs is also desirable. While some programs are developing their own graduation examinations, since most of the UTC students already take the Fundamentals of Engineering exam before graduation, this was chosen by the Electrical Engineering faculty as being an appropriate tool for objective evaluation of student performance in the areas covered (arguably covering ABET a, e, f, and k). The difficulty was, in a small program such as the one at UTC, how to use the results to produce an objective measure. The evaluation of the FE results had been done in an *ad hoc* way for several years. However, in spring 2002, a process was devised to compare UTC Electrical Engineering students' scores, both individually and as a group, to the national averages by a comparison of the number of standard deviations away from the national averages UTC's EE students were in

different categories. Any area in which the students score two or more standard deviations above the national average is labeled as "HI" and any area in which the students are two or more standard deviations below the national average is labeled as "LO." As the number of students currently in the program is small, setting percentage goals at this point is impractical. However, each semester, the evaluation results are discussed by EE faculty and examined for trends and evidence of weaknesses in the program. An example of the type of data generated each semester from the FE results is shown in Figure 1 [4]. The danger in such a small program is over-generalizing from the small number of students taking the exam; however, for a larger program, where the results may be statistically significant, this could be used as a quantitative, rather than qualitative measure.

EE's Number taking exam = 2 Number passing exam = 2

Topic	UTC	State	Nat'l	Nat'l Sdev	UTC StD fm Nat'l	NOTICE
Chemistry	50	49	55	2.31	-2.16	**LO**
Computers	74	71	71	1.64	1.83	
Dynamics	61	56	58	1.86	1.61	
Elec. Cir.	75	68	70	2.08	2.40	**HI**
Engr. Econ.	70	58	61	1.32	6.82	**HI**
Ethics	70	65	65	1.09	4.59	**HI**
Fluid Mech.	56	37	39	1.43	11.89	**HI**
Materials	69	48	54	1.76	8.52	**HI**
Math	67	63	64	4.08	0.74	
Mech. Materials	38	39	39	1.44	-0.69	
Statics	58	48	51	2.34	2.99	**HI**
Thermo.	50	38	41	4.09	2.20	**HI**
Average	62	53	56	2	2.75	**HI**

Figure 1. UTC Electrical Engineering FE Results from Spring 2002 [4]

Look at What You Can Add Without Placing Additional Burden on the Faculty

There are certainly some cases where no sufficient amount or type of data exists which can be used for the required ABET assessment. In this case, the commonsense goal is to collect information in such a way that an unrealistic burden is not placed on faculty. One such example would be the design portfolios described in the section above: the burden for development of the portfolio is placed on the individual student rather than on faculty--the faculty are only required to review the portfolios of their advisees. So long as students are informed from the beginning of the program that it is their responsibility to produce an acceptable design portfolio as a requirement for graduation, and are periodically reminded, this will also not be an undue burden on the student--it is only when the student tries to produce the portfolio immediately preceding graduation, from work in previous years, that this becomes a difficulty.

A measure of how well-prepared students feel to join the engineering work force, just prior to graduation, is viewed by many as a valuable means of assessing outcomes. Two possible means of accomplishing this are senior surveys and exit interviews. While exit interviews may be impractical for larger programs, they would be possible in programs with a relatively small student/faculty ratio. A survey, however, could be applied to a program of any size, and may produce more objective results than an interview, which might have different results depending on who conducted the interview, and how consistently it was done. Such a survey can be implemented with a minimum of faculty effort. At UTC, the Electrical Engineering faculty selected a required course which each student must take in the senior year. During one class period near the end of the semester, the professor teaching the course administers the survey. Results are tabulated and put into a spreadsheet with results from previous years to make trends easy to find. The major faculty involvement required in this process, after the development of the

survey itself, is in examining the multi-year results, discussing trends, and suggesting changes based on results. This is easily accomplished as part of a regular faculty meeting.

Since objectives must also be measured, most universities feel that contact with alumni is imperative; this is also most easily done by survey, especially in large programs. However, with an efficient administrative support staff, this poses little work for faculty. After selecting the point at which graduates should be surveyed, with 3-5 years being the common range at which faculty in most programs feel that graduates will have reached journeyman level, surveys can be prepared and sent once per year, or on whatever schedule the program and its constituents feel is most appropriate for the needs of the program. Again, once the responses are received, results are tabulated and added to previous years' data in a series of graphs, or in some other form in which trends are easily observed. Only then, the faculty analyze, discuss, and act on information received. UTC's Electrical Engineering program has observed a higher return rate when surveys are conducted by email rather than traditional paper implementations, with alumni seeming to prefer ease of response to complete anonymity.

Make Everything You Do Count

Surveys are a useful tool for assessing both outcomes and objectives, although surveys alone are not sufficient evidence of success from an ABET viewpoint. However, if surveys do not ask the right questions, they serve no useful purpose. One program was observed to conscientiously conduct end-of-course surveys for every engineering course, but neglected to include questions relevant to ABET-required outcomes, making the process ineffective. Also, how questions are asked, as every political pollster knows, largely determines the outcome. Rather than using "ABET words" for some of the more subjective outcomes, sometimes a thoughtful rewording can better capture the intent of the desired outcomes. For example, the questions from [4]

> What have you learned since graduation that you wish had been covered at UTC?

and

> Have you used any of the following to continue improving your professional skills since leaving UTC?
>
> | | | | | | |
> |---|---|---|---|---|---|
> | graduate classes | short courses | professional societies | on-the-job training | trial and error | other (explain) |

receive a significantly more positive response than

> Are you committed to lifelong learning?

However, the desired behavior, i.e., continuing to learn and improve skills throughout one's professional career, is captured by the former questions as well as in the latter.

While it is tempting, especially when one is first dealing with EC2000, to provide as much information as humanly possible to ABET visitors, measures that create work for faculty but do not provide significantly new information are to be avoided. Would surveying graduates 1, 3, 5, 10, and 20 years after graduation, as one program recently suggested, really provide enough additional information for the program, compared to a single survey 3-5 years after graduation, to justify the work necessary to maintain correct addresses and re-survey the same group again and again? Make each measurement significant enough to justify the work involved.

One common error in this area is in believing that *every* measurement must be conducted on *every* element *every* year. As long as a regular timetable, responsive to the needs of the program constituencies, is established and faithfully followed, some items can be evaluated more seldom. This is especially true of items related to setting of program mission, goals, and objectives, which are generally seen as being part of the "slow" feedback loop of the ABET continual program improvement process. Even for the outcomes, usually included in the "fast feedback" portion of the process, not every item or every course must be assessed yearly. A good general approach would be to select a timetable in which assessments are distributed throughout the year to level the assessment workload, assess each item as often as constituents feel is necessary to demonstrate success or derive input, and distribute responsibility among faculty so that the burden on any one is minimized.

Look at the Big Picture

If at all possible, each outcome and objective should be measured by three or more disparate means. Although this "triangularization" is not officially required by ABET, it is increasingly expected. A useful tool in determining whether each item is sufficiently assessed is an "Outcome-Assessment" matrix. An example of this type of matrix, from [4] is found in the Appendix, where

α = primary assessment
β = secondary assessment
γ = supporting information
* = possible future measures, discussed, but not yet implemented

A tool such as this is not only useful in demonstrating to ABET that all items are being assessed, and assessed by multiple methods, but is also useful in helping the faculty determine whether assessment is adequate in all areas.

Some Caveats

A few additional caveats on the ABET assessment process are as follows:

- Don't list as constituents people from whom you cannot reasonably expect to get input. While it may sound good to list "parents of potential students" or "the state of Tennessee" as constituents, unless you have a plan for collecting data from these groups, this broad definition of constituents can harm rather than help.

- Employers can be a rich source of information on former students working for them, but many are prevented from providing information directly due to privacy concerns. While larger industry meetings or industrial advisory group input may seem less efficient and more time consuming than an employer survey, the group methods may actually be a more effective means of generating information.

- More isn't always better. Keep information provided to ABET visitors to the amount necessary for them to evaluate what you're doing. Overwhelming the visitor with unnecessary data may actually cause a backlash and decrease chances for success in attaining the results you desire from your accreditation visit.

- Meetings do not always equal progress. Keep the number of faculty meetings related to ABET assessment to the minimum necessary number--overstressing faculty with meetings in which no real progress is made will tend to decrease buy-in from faculty and make the process more, rather than less, difficult.

- Remember that the burden of proof is on you--the ABET accreditation team is not required to show that you do *NOT* meet the requirements; you must clearly demonstrate that you *DO*.

- There are many workshops and consultants offering to guide you through the ABET maze--if you're going to pay for help in ABET processes, shop wisely and make sure you get your money's worth!

CONCLUSION

While EC2000 criteria are not "cut and dried," if assessment is properly conducted, they do not have to place an undue burden on faculty or administration. The simple and straightforward means, methods, and example processes described here have been used successfully in the initial accreditation of Electrical Engineering at UTC, and in the author's work as an ABET accreditation visitor in helping other programs succeed in the accreditation process; yet all can be performed in a small program where the faculty must conduct the assessment processes themselves, without the aid of special staff persons or paid consultants. And while some programs do choose to place assessment in the hands of a consultant or staff specialist rather than having faculty perform the assessment functions, those faculty personally involved will find the processes of continually measuring, discussing, and evaluating program goals, objectives, and outcomes can be very valuable tools for the continuous improvement of the program, and the assurance that the program meets the needs of current and future students, changing with the changing technology and the society it supports.

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Appendix : Outcome vs. Assessment Matrix [4]

EE ASSESSMENT	Senior survey	Degree requirements	Course folders	Gen. Ed. Requirements	Core & Design Sequence	Alumni survey	Employer/ industry surveys	Design portfolio*	FE exam	Exit interviews*	Outside review*	Job offers to graduates
a: apply knowledge of math, science, and eng.	β		α			γ	γ		γ			γ
b: design and conduct experiments	β		α			γ	γ					
c: design a component	β		α			γ	γ					
d: multi-disciplinary teams	β				α	γ	γ					
e: identify, formulate, and solve eng. problems	β		α			γ	γ		γ			γ
f: ethics	α		β		γ	γ	γ		γ			
g: communicate effectively	β		β		α	γ	γ					γ
h: broad education for global context	β			α		γ	γ		γ			
i: lifelong learning	β				γ	α	γ					
j: contemporary issues	α		β	γ		γ	γ					
k: techniques, skills, and modern eng. tools	β		α			γ	γ		γ			γ
EE-1: 1 year of math and basic sciences		α	β									
EE-2: 1.5 years of eng. topics appropriate to EE		α	β									
EE-3: appropriate use of probability and statistics		β	α		γ							
EE-4: breadth in EE		α	β									
EE-5: depth in EE		α	β									
EE-6: advanced math		α	β									

α = primary assessment
β = secondary assessment
γ = supporting information
*** =** possible future measures, discussed, but not yet implemented