Assessing the Effects of the ABET/NSF/Industry Regional Faculty Workshop*

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In 1998, the Accreditation Board for Engineering and Technology, Inc. (ABET®) implemented Engineering Criteria 2000 (EC2000). To support implementation, ABET is conducting a series of regional engineering faculty workshops. This paper focuses on how assessment was used to improve the structure of the workshop and to insure its continued effectiveness in view of the community's evolving awareness and understanding of EC2000. This paper describes the overall project methodology and implementation. Results reported include survey data from nine of 12 workshops. For the one-year post workshop results, data from the first four workshops are reported.

INTRODUCTION

OVER THE PAST DECADE, a revolution has been underway in engineering education in the United States. Spurred on by the changing needs of industry and the recognition by engineering educators that the current educational process may not be responsive to those needs, visionary leaders within the engineering education community began taking a hard look at the quality of engineering programs in the US. Technical proficiency is only part of the skill set needed by today's engineering professional. There is a need for a new engineering education paradigm whereby students will acquire characteristics in addition to technical skills, such as communication skills, the ability to work on teams, and an understanding of the impact of engineering solutions in a broad societal, environmental, economic, and ethical context [1]. The challenge is how to stimulate and implement innovation in curriculum and instructional delivery; many engineering programs have been reluctant to implement large-scale reforms due to the perceived risk to the accreditation status of the program.

In concert with its member societies, the Accreditation Board for Engineering and Technology (ABET) is responsible for establishing standards, procedures, and an environment that will encourage the highest quality for engineering, engineering technology, computing, and applied science education through accreditation so that each graduate possesses the skills necessary for life-long learning and productive contribution to society, the economy, employers, and the profession. In 1992, ABET, in partnership with industry, academe, and the professional engineering societies, embarked upon a revolutionary accreditation reform initiative. The reform effort would encompass criteria, process, and participation. In 1994, consensus-building workshops were held in each of those three areas. Recommendations for action came out of each workshop. The participants from the Criteria Reform Workshop reached overall consensus on the desirability of new criteria that were more flexible. These criteria should allow for the uniqueness of each institution while providing a threshold for entry into the profession. The participants of the Criteria Reform Workshop agreed that the Engineering Accreditation Commission (EAC of ABET) should move toward some form of outcomes assessment as part of the accreditation requirements. That recommendation became a reality in 1996 as *Engineering Criteria 2000* (EC2000), outcomes-based criteria for the evaluation of engineering programs, was developed. These revolutionary criteria focus on engineering program outputs—not inputs—on what the student learns, not only what the teacher teaches. Workshop participants recommended further that engineering accreditation should be based on ongoing institutional processes for defining educational objectives, evaluating achievement of objectives, and improving educational effectiveness, with periodic external reviews of the process by ABET. It should also ensure a broad education that emphasizes the basics, encourages life-long learning, and inculcates desirable experiences and capabilities. These recommendations are reflected in EC2000 Criterion 2, 3, and 4 as follows:

Criterion 2: Program Educational Objectives

Each engineering program for which an institution seeks accreditation or reaccreditation must have in place [2]:

- detailed published educational objectives that are consistent with the mission of the institution and these criteria;
- a process based on the needs of the program's various constituencies in which the objectives are determined and periodically evaluated;
- a curriculum and processes that ensure the achievement of these objectives;
- a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program [2].

The result of the process would be to strive for internal excellence rather than simply meeting a set of external minimum standards. Criteria should specify a limited set of educational objectives for any engineering program and a limited 'floor' for curricular content. Complete objectives, curricula to achieve them, and processes to evaluate achievement would be defined by the institutions. Criteria should include a core, consisting of a knowledge base and an experience base. This core should uniformly define what it takes to become an engineer.

Criterion 3: Program Outcomes and Assessment

Engineering programs must demonstrate that their graduates have:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to design and conduct experiments, as well as to analyze and interpret data;
- an ability to design a system, component, or process to meet desired needs;
- an ability to function on multi-disciplinary teams;
- an ability to identify, formulate, and solve engineering problems;
- an understanding of professional and ethical responsibility;
- an ability to communicate effectively;
- the broad education necessary to understand the impact of engineering solutions in a global and societal context;
- a recognition of the need for, and an ability to engage in life-long learning;
- a knowledge of contemporary issues;
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Each program must have an assessment process with documented results. Evidence must be given that the results are applied to the further development and improvement of the program. The assessment process must demonstrate that the outcomes important to the mission of the institution and the objectives of the program, including those listed above, are being measured. Evidence that may be used includes, but is not limited to the following: student portfolios, including design projects; nationally-normed subject content examinations; alumni surveys that document professional accomplishments and career development activities; employer surveys; and placement data of graduates [3].

Criteria should also define what constitutes the minimum content of an engineering curriculum.

Criterion 4: Professional Component

The professional component requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The engineering faculty must assure that the program curriculum devotes adequate attention and time to each component, consistent with the objectives of the program and institution. Students must be prepared for engineering practice through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints that include most of the following considerations:

- economic
- environmental
- sustainability
- manufacturability
- ethical
- health and safety
- social
- political.

The professional component must include:

- one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline;
- one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study;
- a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives [4].

Adoption of totally new criteria was only half the initiative. Criteria Reform Workshop participants recommended that the EAC should provide advice to institutions attempting to define the needed measurements and outcomes. During pilot visits for EC2000 implementation, it became clear that engineering faculty would not take substantial steps toward a new educational paradigm until they were confident that their programs could successfully meet the requirements of EC2000. The key to a successful paradigm shift rested then with the faculty as providers of the educational experience. Faculty must be comfortable that they can make innovative curricular changes and assess outcomes consistent with EC2000. The ABET/NSF/Industry Regional Engineering Faculty Workshops were intended to address the need to assist faculty in understanding the basics of

continuous program improvement and to apply this process on their own campuses.

WORKSHOP SCOPE AND STRUCTURE

The goal of the ABET/NSF/Industry Regional Engineering Faculty Workshop project (NSF Award # 9812888) was to facilitate educational innovation and adoption of new educational paradigms within US engineering education programs. Specific project objectives were the following:

- to build confidence and skill to develop objectives and outcomes, an assessment plan, and a feedback mechanism to meet the requirements of EC2000;
- to develop case studies to assist institutions and provide training materials for program evaluators;
- to create a network of faculty assisting in the exchange of information on best practices in assessment and innovation;
- to strengthen ties with industry and determine ways to gather information on the changing needs of the employers of engineering graduates.

The paper describes the overall project methodology and implementation as a backdrop for focusing on the assessment process used in the workshop project. The paper reports the findings from the workshop exit surveys conducted to date for nine of the 12 workshops and the one-year post workshop survey conducted for four of the 12 workshops with recommendations for future directions.

The workshop project was designed as a series of 12 workshops to be conducted in different regions around the United States over a three-year period beginning in December 1998. ABET invited two faculty members from 30 institutions with engineering programs in each region. The goal was to include faculty from every institution with engineering programs by the end of the three-year workshop project. Each two-day workshop would accommodate 75 participants: 60 engineering faculty, in addition to EC2000-trained team chairs and program evaluators, professional society observers, an assessment expert, and industry continuous improvement representatives.

As part of the project, ABET sought to continue the partnership among itself, the institutions, and industry begun with the consensus building workshops. The NSF funding provided support for workshop content and materials development and a fixed sum for participant travel support. ABET's industry partners for the workshop project were:

- Boeing Co.,
- Burns and McDonnell Intl.,
- Corning, Inc.
- EMC Corp.
- Exxon Mobil

- Ford Motor Company
- Global Wireless Education Consortium (GWEC)
- Law/Gibb Group
- Maytag, Inc.
- Motorola
- Norfolk Southern
- Raytheon
- Structural Dynamics Research Corp. (SDRC)
- TRW Corp.

In addition to providing logistics support for the workshop, each industry host was asked to provide a senior engineering executive to deliver a keynote address and two industry representatives with experience in quality improvement implementation in the host company. The idea was to get faculty into the work environment of these companies and to provide industry with an opportunity to interact with faculty from regional institutions. The keynote address was designed to inform faculty about the current state of engineers in the workplace:

- typical responsibilities;
- career paths;
- key skills required;
- criteria for entry-level hires.

These presentations provided a foundation for the faculty to begin examining continuous program improvement as a component of EC2000. ABET provided volunteer expertise and staff support for development and management of the workshop project. Institutions were asked to contribute by providing travel support for their two participants.

The workshop design and materials were pilot tested at the 1998 ABET Annual Meeting. The inaugural workshop was held in Atlanta, GA, December 1998. To date, nine workshops have been conducted, and the final three are to be completed by the end of this year. Of the 328 eligible institutions with engineering programs, 268 have been invited to send participants to the workshop. A total of 420 faculty members have attended the nine workshops conducted thus far.

On Day One of the workshop, after the brief keynote address by the sponsoring industry partner, faculty members were divided into small discipline-specific groups (4–7 faculty members). Discipline-specific groups are used because ABET accredits discipline-specific programs. No two faculty members from the same institution were included in the same small group to assure diversity of perspectives. Guided by a trained facilitator experienced in the implementation of EC2000, each small group worked through a series of interactive exercises based on one of two fictional case studies provided as pre-reads along with the EC2000 document. These exercises were designed to get the workshop participants to critique sample program educational objectives, program outcomes, and assessment/evaluation plans. Industry experts on quality management and an assessment expert were available to assist

the small groups as they worked toward a consensus response for each exercise. Each group was required to record their work, and one group was selected after each exercise to report back to all the participants. Through a series of open-ended questions, the workshop leader guided the whole group to a new level of understanding about a particular assessment component.

On Day Two of the workshop, the participants were given a third fictional case study. In the same small discipline-specific groups, they were instructed to develop program educational objectives, outcomes, and assessment/evaluation plans using the knowledge they had gained the previous day. Once again the groups were required to record their work for a report back to the larger group. To close the workshop, each group was asked to identify the top five 'Points of Learning' that participants would take away from the workshop. These were shared in the larger group. The leader reviewed with the participants a series of 'Lessons Learned' from the EC2000 Pilot Visits and the first round of implementation visits.

The exercises were designed not only to transmit content knowledge about the outcomes-assessment process but also to engage faculty members in the learning process. The workshops were an opportunity to demonstrate how faculty can engage their students in the educational experience rather than students sitting passively accepting information from the 'expert.' On the first day, this approach created a certain level of discomfort among the faculty participants who were seeking the 'right' answer. Comments from many feedback surveys claimed they felt as if 'the blind were leading the blind'. By the second day most were fully engaged in not only the acquisition of knowledge but in the methodology the workshop was using.

Faculty members were already familiar with assessment at the classroom level. While they could relate to course level assessment in the form of tests, quizzes, graded student work, and end-of-course assessments completed by students, they were less familiar with a process to assess the educational program as a whole. One might call it the 50,000-foot view. Much of the assessment conducted at the program level is done informally and on an ad hoc basis. Administrators and faculty can point to curricular revisions as one sign that program assessment is conducted at some level. What prompted the revision? Would the change enhance the program? Would the graduates perform as constituents expect? These questions were not addressed. However, EC2000 requires a systematic approach to program assessment, one that is formalized and documented throughout the program, one that requires addressing those very questions.

The workshops were designed to build upon the assessment knowledge faculty members already possessed by getting them to use it as a foundation for expanding their understanding of assessment from course-level to program-level. This approach

to learning known as constructivism purports that learning is an active endeavor rather than a passive one. Teachers encourage group interaction, where the interplay among participants helps individuals become explicit about their own understanding by comparing it to that of their peers. [3] The teacher (workshop leader) no longer acts as the 'talking head' expert, but assumes the role of mentor, guiding the students (participants).

This perhaps is explained best by adapting the key tenets of constructivism as developed by Martin Dougiamas (*A Journey Into Constructivism*, 1998) [4]:

- Faculty members come to the workshop with an established world-view, formed by years of prior experience and learning.
- Even as it evolves, a faculty member's world-view filters all experiences and affects their interpretation of observations.
- For faculty members to change their world-view requires work.
- Faculty members learn from each other as well as the workshop leader and facilitators.
- Faculty members learn better by doing.
- Allowing and creating opportunities for all to have a voice promotes the construction of new ideas.

Therefore, the discomfort felt by the faculty during the Day One exercises and the search for the 'right' answer from the expert were normal reactions for participants. For the majority of faculty this was not how they were taught or how they teach their students. By using the constructivist approach in the workshops, the faculty participants were actively engaged in making the components of assessment understandable within their own context, while the workshop leader focused on what the faculty participants '. . . can analyze, investigate, collaborate, share, build, and generate based on what they already know, rather than what facts, skills, and processes they can parrot' [4]. Since there is more than one way to approach continuous program improvement and assessment, using a constructivist approach to the discovery of that knowledge was most effective. The workshop placed the responsibility for what is learned and how to learn on the faculty participant with the leader, facilitators, quality, and assessment experts there to provide guidance whenever necessary. This approach provided faculty participants with multiple perspectives so that they could explore several alternatives before they built up their own understanding [5]. Ultimately, using a constructivist approach in the workshop exercises provided faculty with an example of a different way to teach.

WORKSHOP ASSESSMENT

Assessment and evaluation for the workshop project were done in two phases: at the conclusion of each workshop conducted and one year after the

return to campus, using survey instruments developed by senior personnel on the grant. The workshop assessment had four objectives:

- to determine the participant's perception of the value of the specific workshop exercises;
- to determine the participant's perception of the overall value of the workshop experience;
- to determine the participant's perception of how well prepared he/she is to engage in each of several assessment tasks;
- to what degree the ABET workshop contributed to his/her preparation/ability to perform each of these tasks.

Results reported include data collected from nine of 12 workshops already conducted, and for the first one-year post workshop assessment, data from four of 12 workshops are reported.

Since the workshop project would take place over the same three-year period as the phase-in for EC2000, project leadership assumed that some of the content, and thus the exercises, may need to change as more faulty members became familiar with EC2000 and continuous program improvement while undergoing accreditation on their campuses. In order to provide for continuous improvement of the workshop program, an exit survey was developed and administered to each group of participants at the conclusion of the workshop. The seven-item survey instrument asked for a quantitative ranking, using a scale of one to five with five being the greatest, of the effectiveness of each exercise both as a stand alone and as preparation for the subsequent exercises. In addition, participants were asked for improvement suggestions and to rate their overall satisfaction with the workshop experience by indicating if they would recommend the workshop to other faculty members. The seven questions were as follows.

Workshop exit survey
1. Several exercises during the first day asked you to identify the good and bad features of two example materials and then to identify attributes of good statements. Is this process of evaluating examples and developing a list of attributes a good method for preparing faculty to compose such statements?
2. Did the exercises on developing an evaluation plan and an assessment plan add to your understanding of what needs to be done in your program to prepare for EC2000?
3. Overall, did the first day's exercises help you to be better prepared for composing materials on the second day?
4. During the morning of the second day each group was asked to compose materials based on a hypothetical situation. Did you find the use of a hypothetical situation a practical pedagogical method for helping you learn to compose the subject materials?
5. During the afternoon of the second day the group spent time discussing evaluation and

assessment methods and processes and strategies for composing materials for part of a Self-Study Report. Did you find this discussion helpful?
6. Overall, did the second day's exercises help you to be better prepared for meeting the requirements of EC2000?
7. Would you recommend to faculty members at other institutions that they should participate at a future workshop in their region?

Data gathered from the first workshop is shown in Table 1. Data gathered from the next eight workshops are shown in Table 2. Following the first workshop the number of survey questions was reduced to seven, based on changes made to the workshop content after the first workshop.

The workshop leadership identified the following independent variables as having a possible impact on survey results: the region where the workshop was held, the number of participants in the large and small groups, the discipline of the small groups, the size of the programs and types of institutions represented, the facilitators, and how soon the program expected to undergo an EC2000 visit. In order to minimize the effect these variables might have on the survey, a de-briefing was also held after each workshop with the leader, facilitators, the assessment expert and ABET staff to gather qualitative data on the overall perceived effectiveness of the workshop. The goal was to identify which parts of the workshop were working as planned and which would need to be adjusted for effectiveness.

Getting feedback from participants as they left the workshop only provided half the picture. In order to begin to assess the overall effectiveness of the workshop project, ABET needed to determine the participants' perceptions of how well prepared they were to engage in each of several tasks and to what degree the ABET workshop contributed to their preparation/ability to perform each of these tasks. To gain this feedback, workshop participants were contacted a year after they attended the workshop.

The first round of post-workshop assessment was conducted as a web-based survey of the faculty participants from the first four workshops (1998–1999). The survey was designed and administered by an external expert so that respondents could feel comfortable providing frank answers.

Table 1. Survey results from the Atlanta EC2000 Regional Faculty Workshop

Question 1	3.4
Question 2	3.8
Question 3	4.4
Question 4	4.5
Question 5	4.2
Question 6 (Exercise to develop self study elements)	3.8
Question 7	4.3
Question 8	4.7

$N = 56$ (62 attendees)

Table 2. Survey results from the next eight workshops

Survey Question	Seattle N = 46/47	Charlotte N = 47/53	Kansas City N = 51/58	Florham Park N = 32/40	Phoenix N = 40/43	Houston N = 39/42	Newton N = 43/49	Redondo Beach N = 19/26
Question 1	4.2	4.1	3.8	4.5	4.5	4.7	4	4.7
Question 2	4.5	4.4	4	4.7	4.5	4.8	4.4	4.6
Question 3	4.2	4.3	4.1	4.7	4.4	4.8	4.3	4.5
Question 4	4.4	4.2	3.9	4.4	4.6	4.6	4.5	4.2
Question 5*	3.5	3.6	3.3	3.6	4.2	4.4	4	4.1
Question 6	4.4	4.3	4.3	4.5	4.5	4.8	4.5	4.7
Question 7	4.7	4.6	4.7	4.8	4.9	5	4.8	4.8

*This question asked for feedback on the revised Day Two activities.
N = Number of surveys collected/Number of Attendees

Questions asked were related to the assessment objectives stated above. The survey used the following scale: 0 = Don't know, 1 = Not at all, 2 = Little, 3 = Moderately, 4 = Well. Each respondent was asked to (a) rate how well prepared they are for the task listed below, and (b) rate how well the ABET workshop contributed to that preparation. The seven tasks reflected the content of the workshop (survey questions 1–7):

1. Development of educational objectives.
2. Development of an assessment plan.
3. Design of a quality improvement process.
4. Ability to implement curricular and instructional reform.
5. Ability to assess the effect of curricular and instructional reform.
6. Strengthen ties with industry to gather information on changing needs of employers of engineering.
7. Engage other program faculty in the process.

The participants' perceptions of preparedness is shown in Fig. 1. In addition, the survey also asked the participants to rank the helpfulness of a variety of resources including the workshop. The participants' ranking of the usefulness of various assessment resources, including attendance at the workshop is shown in Figure 2.

Information was collected from the participants that would correlate to some of the independent variables mentioned previously: type of institution, workshop attended, etc. A total of 260 workshop participants were invited to participate in the survey. There were 105 complete responses from a 40% return rate.

FINDINGS

The original workshop design provided for six interactive exercises over a two-day period. Based on the data from the first exit survey and the workshop leadership debriefing, the most radical revision occurred after the first workshop. While the survey results were very positive with the average response for each question above three, participant comments indicated that the amount of work required during the two-day period was too
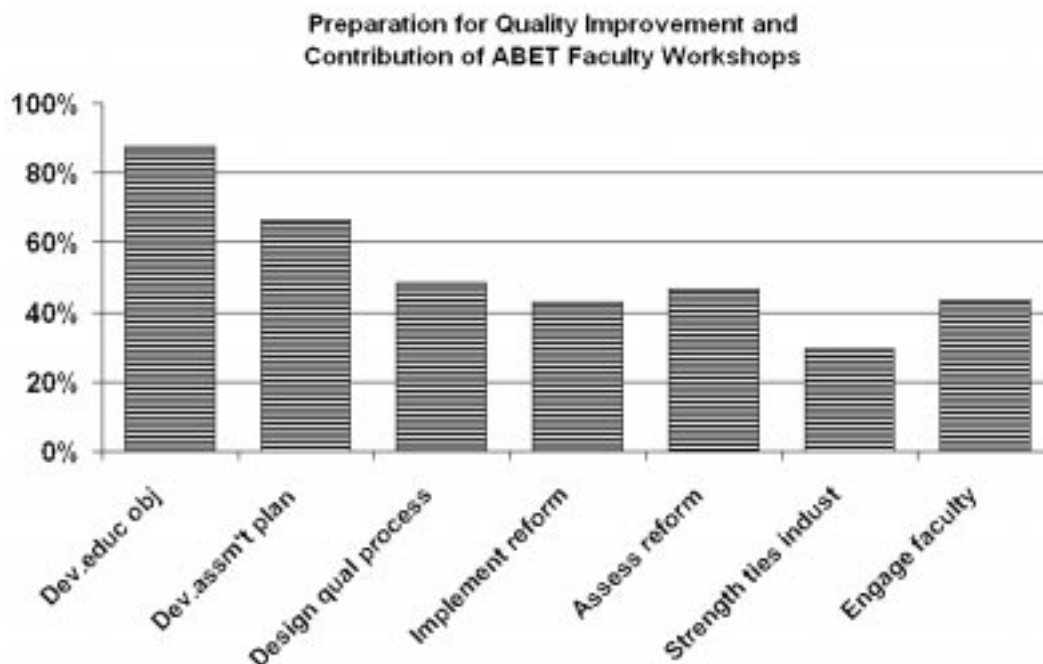

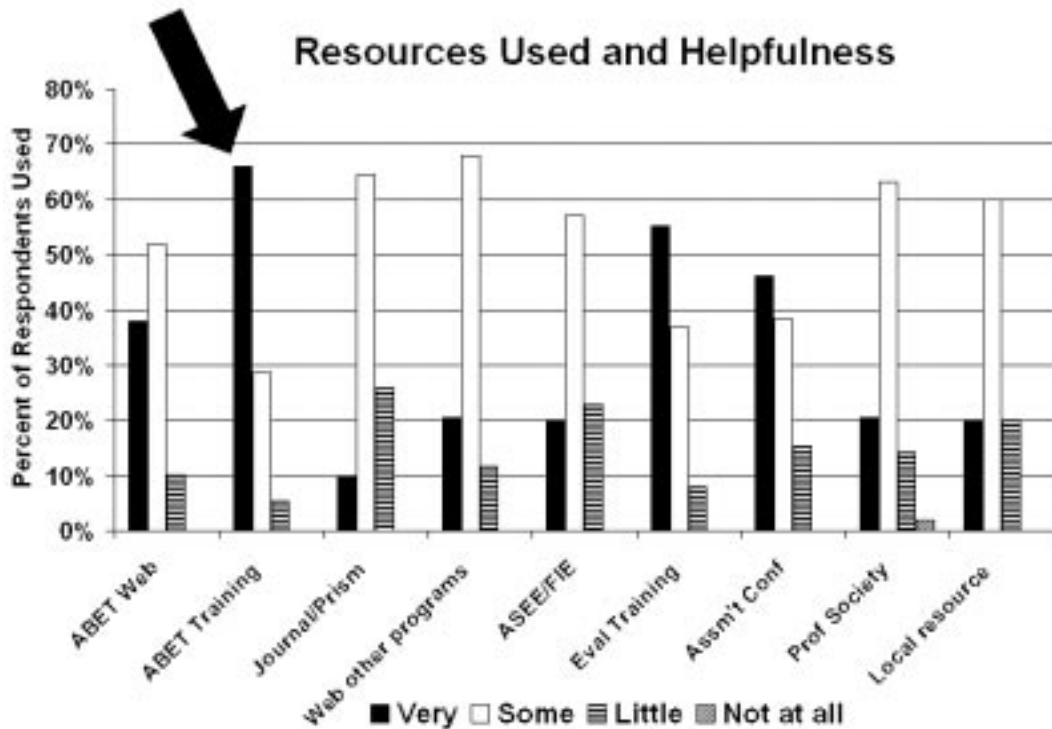Fig. 1. Workshop participation and perceived task preparedness.

Fig. 2. Assessment resource usefulness.

much to handle in the small group setting. Participants cited their struggle with assessment terminology that was new to them as the main factor contributing to this. The de-briefing with the leader, assessment expert, facilitators, and ABET staff pointed to the performance criteria exercise as being the most troublesome for the participants to grasp. In addition, the Day Two exercise requiring participants to develop program educational objectives, program outcomes, and assessment/ evaluation plans plus sample self-study elements for a new fictional case study needed to be scaled back to allow for a more effective experience. As a result, the Day One performance criteria exercise and the self-study development segment of the Day Two exercise were dropped. Facilitator's instructions were changed to give more direction to the Day Two exercise. With the change in the workshop, the exit survey was adjusted to reflect the revised program.

Upon implementation of the changes outlined above, the effectiveness of the workshop exercises for the subsequent eight workshops was consistently high. Based on written comments for improvement provided in subsequent surveys, additional adjustments were made to the program but nothing significant enough to require a change in the exit survey. One persistent issue was the lower rating for the Day Two afternoon portion of the workshop dealing with self-study issues (question 5). After analysis of the consistently low ratings and accompanying comments, the leader and facilitators concluded that the participants were simply worn out after the intense experience of the past day and a half. Still, the leadership

group looked to provide something of value to round out the workshop program. At the December 1999 workshop, a module on assessment was added. As demonstrated by the increase in question 5's average response over the next several workshops, the module performed as hoped.

When asked if they would recommend attendance at the workshop to faculty members in another region, the response across all workshops was consistently high at 4.8 (question 7). This is perhaps the single most telling indicator of overall satisfaction with the workshop. Faculty participants consistently left the workshop feeling they had gained important experience for addressing continuous improvement on their campuses and would recommend the workshop program to other faculty.

Analysis of the data collected from the one-year post workshop survey revealed that the participants perceived a strong relationship between how prepared they felt to develop educational objectives, outcomes, and assessment plans (Survey questions 1–7) and how well they perceived the workshop had contributed to that preparedness. Conversely, as they began to implement reform on their campus, assess the reform, engage faculty, and strengthen ties with industry, their confidence to engage in those tasks decreased. An overwhelming percentage of the participants ranked the workshop highest when they were asked to rate the helpfulness of the workshop when compared to other resources available in implementing continuous improvement (survey question 10 with all its subsets). Regional differences (which workshop

attended) appeared to have no effect on responses to task preparedness. There appeared to be no difference between the groups who had already had an EC2000 visit and those who had not.

As requested in the survey, 53% of the respondents reported example improvements made as a result of their efforts for continuous program improvement. The following represent a sampling of these reported improvements:

- Laboratory sequence restructured to provide more hands-on experience for the students.
- Standardized instruments so results can be compared over a span of years.
- Modified objectives and changed assessment procedure.
- Feedback from senior surveys used to revise freshman core courses.
- Feedback from national engineering advisory board used to check objectives; modifications underway.
- Addressed weakness in the area of statistics found through industrial advisory board and outcomes/course matrix.
- Developed a system to evaluate and track students' writing skills.

CONCLUDING REMARKS

The assessment conducted to date confirms that the workshop is a valuable experience for building faculty confidence in developing program educational objectives, program outcomes, and assessment/evaluation plans. Faculty participants come looking for the 'assessment cookbook' but, in their perception, go away from the workshop with a better understanding of outcomes assessment and its application to program development and continuous improvement. From that perspective,

the workshops are performing as designed. The interactive exercise methodology employed by the workshop program is well received and has allowed faculty to work effectively in small groups (4 to 7 faculty members). After completing the workshop, faculty express their recognition of the collaborative process that ABET is fostering through the implementation of EC2000 for improvement in engineering education. The workshop has not however, in the perception of participants, given them what they need to implement reform and carry out the assessment, engage other faculty in the assessment process, or strengthen ties with industry. While it is obvious that the reform initiative begun with EC2000 is multi-faceted and that faculty may require additional assistance in order to successfully innovate engineering education in the US, the workshops have provided a critical first step in the implementation process.

The goal of the ABET/NSF/Industry Regional Engineering Faculty Workshop project (NSF Award # 9812888) was to facilitate educational innovation and adoption of new educational paradigms within US engineering education programs. While it will take a more comprehensive, longer-term assessment study to determine actual achievement of this goal, indications are that some early results are already being seen as noted above. How innovative these changes are or whether they will stand the test of time are questions beyond the scope of this report. Yet based on the assessment data, workshop participants are moving forward to implement continuous program improvement despite their perception that implementation is not easy at this time. After attempting implementation on their campuses, an overwhelming majority of workshop participants still perceive the workshop as the most helpful resource in assisting them in implementing an assessment process on campus.

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