Abstract

This paper provides an overview and progress report on a national study of the impact of ABET’s EC2000 accreditation criteria on student learning in engineering programs. Sponsored by ABET, the study addresses the question, “Are the engineers who complete undergraduate programs under the EC2000 accreditation criteria better prepared for careers in engineering than those who graduated before implementation of EC2000?”

A major focus of the study is the examination of student learning outcomes, defined by EC2000 Criteria 3.a-k, for engineering graduates educated in pre-EC2000 and post-EC2000 programs. The study also assesses the impact of EC2000 on engineering program curricula, instruction, faculty cultures, and administrative policies and practices.

Seven disciplines - aerospace, chemical, civil, computer, electrical, industrial, mechanical engineering – were selected for study. Because there is little existing data that can be used to assess the a-k outcomes, surveys and interviews are being used to collect original data. Approximately 1400 program chairs and faculty members in more than 200 programs – in 40 participating institutions – responded to surveys in fall 2003. Approximately 11,500 graduating seniors (anticipated degree date of Spring 2004) and approximately 9,000 alumni (who graduated in 1993-94) from those same programs are being surveyed in early 2004. Telephone interviews of deans and a survey of employers will be conducted in summer 2004.

This paper presents information about the research design of the EC2000 Study, describing the sampling plan, instrument development process, survey administration, data collection and management, and planned analyses. It also provides information about the anticipated uses of the findings of the EC2000 Study.

Introduction

In the early 1990s, the Accreditation Board of Engineering Education (ABET), through its Accreditation Process Review Committee (APRC), examined existing accreditation criteria and processes, and presented proposals for change. The primary reason for this reform was the
perceived mismatch of industry needs and the skill sets of graduates of engineering programs\(^1\). In addition, it was widely believed by members of the engineering education community that ABET’s content-focused accreditation criteria were a barrier to curricular and pedagogical innovation\(^2\). New standards that emphasized clear educational objectives, industry collaboration, outcomes assessment, and continuous improvement were needed\(^3,4\).

With aid from the National Science Foundation, ABET brought together groups of stakeholders from higher education and industry in a series of workshops to develop the new accreditation standards\(^5\). In 1996, a revised set of criteria for program accreditation was approved. The standards included common criteria for all engineering programs and program specific criteria for 24 engineering sub-disciplines\(^5\).

The revised accreditation standards aim to maintain emphasis on the development of students’ technical (i.e., mathematical and scientific) knowledge base, but additionally stress the development of professional skills such as communication, teamwork, and group problem solving. The new standards also shift focus away from a checklist approach that emphasized meeting standards for curricula, resources, faculty, and facilities, and encourage a new focus on students’ educational outcomes. The new standards, known as EC2000, are expected to stimulate significant restructuring of curricula, instructional practices, and assessment activities in engineering. Evidence of student learning, specifically, those outcomes articulated in Criterion 3, is now a central requirement for accreditation\(^5\).

In spring 2002, ABET contracted with members of the faculty at the Center for the Study of Higher Education at Penn State to assess the impact of EC2000. The research team was asked to design a study that would answer the following question: “Are engineers who are educated in programs responding to the EC2000 accreditation standards better prepared for careers in engineering than their counterparts who were not educated in such programs?” The resulting project, entitled Engineering Change: A Study of the Impact EC2000, is a three-year effort that will ascertain whether ABET’s EC2000 has influenced student learning in a representative sample of engineering programs in seven disciplines.

A National Advisory Board for the EC2000 Study, comprised of 14 members who represent both academic and industry perspectives on engineering education, provides counsel and advice to the research team. To date, the National Advisory Board and research team have addressed questions and issues related to the study design, data collection strategies, and instrumentation. The membership of National Advisory Board is listed Appendix A.

This paper presents information about the research design of the EC2000 Study, describing the sampling plan, instrument development process, survey administration, data collection and management, and planned analyses. It also provides information about the anticipated uses of the findings of the EC2000 Study.

**Overview of the EC2000 Study**

The EC2000 study is national in scope. It is aimed at accredited engineering programs in selected fields within a representative sample of institutions, and is designed to compare pre-
EC2000 and post-EC2000 information on engineering programs and student learning. The project targets programs in seven engineering disciplines – aerospace, chemical, civil, computer, electrical, industrial, and mechanical engineering. This array provides the opportunity to study those disciplines that have traditionally produced the vast majority of engineering graduates in any one-year (chemical, civil, electrical, and mechanical), as well as disciplines with strong ties to particular industry sectors (aerospace, computer, and industrial).

The conceptual framework for the study of EC2000 assumes that changes in student learning will occur because engineering programs have modified curricula, instructional practices, institutional policies, and even faculty cultures in a manner consistent with EC2000. The linkages are, in this sense, indirect: preparation for an EC2000 accreditation results in curricular and other changes that in turn affect student learning. Figure 1 portrays the hypothesized relationships among the new EC2000 accreditation standards, engineering programs, and student learning outcomes. To confidently attribute any changes in engineering graduates’ learning outcomes over time to EC2000, this study examines these potential sources of influence on student learning. If the study reveals that changes in programs and institutions consistent with the model, the engineering education community will have evidence that these improvements are a consequence of EC2000 rather than the result of other factors that might influence engineering education (such as state performance funding, industry pressures, market competition, or institutional initiatives unrelated to EC2000).

Based on this conceptual model, the following evaluation questions guide the EC2000 Study:

- What impact, if any, has EC2000 had on student learning outcomes in ABET-accredited programs and institutions?
- What impact, if any, has EC2000 had on organizational and educational policies and practices that may have led to improved student learning outcomes?

For the purpose of the study, student learning is defined in terms of the 11 learning outcomes identified in EC2000 Criterion 3 and one additional outcome that was added by the Penn State research team because it is often discussed in the engineering education literature. Compared to engineers prepared under previous guidelines, engineers educated in EC2000-accredited programs should exhibit superior levels of competency in the 11 learning outcomes identified in Criterion 3 of the accreditation standards.

EC2000 emphasizes the need for continuous improvement practices in engineering programs. The assessment of student learning outcomes is one dimension of quality assurance; however, by focusing the attention of faculty and program administrators on the educational experiences of students, EC2000 encourages revisions in courses and teaching methods. Curricular and instructional changes are therefore likely to provide the first evidence of the impact of EC2000 as engineering faculties respond to the findings of their internal assessments by adjusting elements of their programs. Over time, curricular and pedagogical innovations in the spirit of EC2000 should produce increases in students’ levels of knowledge and skill in the areas emphasized in Criterion 3.

To assess the impact of EC2000 on engineering programs and student learning, the researchers are collecting evidence on curriculum and instruction and student learning from a number of
stakeholder groups: faculty in engineering programs, program chairs, engineering deans, graduating seniors, alumni, and employers. Each of these groups contributes to one of the following components of the study.

1) *Program Chairs/Faculty/Deans component:* Program chairs and faculty in the seven focal engineering disciplines will provide program- and course-level information on changes in curricula, teaching practice, and student learning before and after the implementation of the EC2000 accreditation criteria. The administrative heads of engineering units (typically, the engineering dean) will supply institutional-level perspectives on the impact of the new accreditation process on engineering units.

2) *Student/Alumni component:* Current and former students will provide information on the nature and quality of their learning experiences in engineering programs. Seniors graduating in 2004 will provide information on educational experiences and student learning in post-EC2000 programs. Alumni who graduated in 1993-94 from the same programs will provide pre-EC2000 evidence on these same variables.

3) *Employer component:* Employers of engineers are in a position to compare the preparation, on the a-k and other important learning outcomes, of pre-EC2000 and post-EC2000 engineering graduates.

Later sections of this paper provide information on the data collection strategies and methods for each of these study components.
Study Methods

As noted earlier, the EC2000 Study examines changes associated with the implementation of the new EC2000 accreditation standards in a representative sample of accredited engineering programs in seven engineering disciplines – aerospace, chemical, civil, computer, electrical, industrial, and mechanical engineering. To answer the research questions with confidence, the study must examine institutional functioning and student outcomes before and after EC2000. The impact analysis plan therefore includes measurement of student learning outcomes at two points in time—pre-EC2000 and post-EC2000. Table 1 arrays four different groups of institutions that provide opportunities to evaluate the impact of EC2000 over time. By comparing the performance of graduates from selected engineering programs within these four groups of institutions, the researchers will determine if programs with longer histories of EC2000 accreditation produce more qualified graduates (based on the 11 competencies specified in Criterion 3). In addition, this design will permit the study the impact of institutional readiness for EC2000 (which presumably affected the choice of whether to be accredited under EC2000 before it was required or to wait until it was mandated) on student learning outcomes. A limitation of the study is the reliance on retrospective data at time.

Table 1 Four Groups of EC2000 Institutions

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pre EC2000 Accreditation</th>
<th>Most Recent Accreditation</th>
<th>Next EC2000</th>
</tr>
</thead>
</table>

While the focus of this evaluation is learning outcomes evidenced by graduating seniors and alumni in selected engineering disciplines, these institutional groupings are important for categorizing programs in terms of their place in the EC2000 accreditation cycle.

Data Sources: The EC2000 study relies on existing and new data. Although existing data from ABET, ASEE, and IPEDS databases contributes to the EC2000 Study database on engineering programs, the majority of data for this research will be collected through surveys of engineering faculty, program chairs, graduating seniors and alumni, employers, and through interviews with deans of participating institutions. Together, these data sources will provide a 360-degree view of the role of the new accreditation standards in preparing students for careers in engineering, particularly in terms of the 11 learning outcomes specified by EC2000. Each data source is discussed below.

Existing Information:

- Institutional, program, and individual member characteristics from the National Center for Education Statistics’ Integrated Postsecondary Education Data System (IPEDS), American Society for Engineering Education (ASEE), and ABET databases, provided information about engineering programs, their students, faculty, and
administrators. This information was used in developing the study sample, and selected variables serve as controls in this study.

New Information:

- **Survey of Engineering Faculty:** Nearly 3,000 faculty were surveyed between November 2003 and March 2004 about changes in their courses, teaching practices, and professional activities over the past ten years; the impact of those changes on student learning; and about their perception of changes in student learning over the ten-year time period.

- **Survey of Program Chairs:** Chairs of 203 engineering programs were surveyed between November 2003 and March 2004. They were asked to describe changes in program policies, curricula, resources, facilities, and faculty activities during the past ten years. They were also asked to assess the abilities of their current seniors and alumni, as well as about changes in student learning attributable to program changes.

- **Telephone interviews with Deans:** In mid-2004, 40 deans will be interviewed about the engineering school and institutional contexts that influenced changes in curricula, programs, policies, and student learning during the past decade.

- **Survey of Graduating Seniors in engineering programs:** Between January and March 2004, approximately 11,500 seniors were asked to assess their educational experiences and their preparation in each of the 11 areas identified in EC2000 Accreditation Criterion 3.a-k.

- **Survey of Alumni/ae of engineering programs:** In spring 2004, approximately 9,000 graduates of pre-EC2000 programs were asked to assess their educational experiences and their preparation in each of the 11 areas identified in Criterion 3.a-k.

- **Surveys of Engineering Employers:** In mid to late 2004, a representative sample of employers will be asked to assess changes, if any, they have seen in engineering graduates’ abilities and capacities since the inauguration of EC2000.

Table 2 demonstrates how each of these data sources contributes to the study, and how each object of study benefits from multiple sources of evidence. Data collection procedures are designed to permit analysis for each of the seven engineering disciplines.

Considerable research done over the past 30 years consistently finds that self-reports of learning and skill development are adequate proxies for objective measures of the same traits or skills. Results vary depending on the traits and instruments examined, however, correlations on the order of .50 to .70 are reported between self-reports and objective criterion measures on such instruments as the ACT Comprehensive Test, the College Basic Academic Subjects Examination, and the Graduate Record Examination.

Self-reports are appropriate for use in quality assurance and performance improvement systems provided five general conditions are met. They are: (1) the information requested is known to the respondents; (2) the questions are phrased clearly and unambiguously; (3) the questions refer to recent activities; (4) the respondents think the questions merit a serious and thoughtful response; and (5) answering the questions does not threaten, embarrass, or violate the privacy of the respondent or encourage the respondent to answer in socially desirable, rather than truthful,
ways. Furthermore, although student self-reports have only moderate positive correlations with objective measures when used to gauge the learning or skill of *individuals*, when aggregated to compare the performance of *groups*, the reliability of self-reported measures is quite high and is generally considered to be a valid measure of real differences in learning between groups.

**Sampling Procedure:** The Penn State Survey Research Center assisted in sampling engineering programs for the study. The project team selected programs for participation in the study based on a two-stage, disproportionate, stratified random sample with a 7x3x2 design. Randomization ensures that each institution in our population had an equal chance of having its programs selected. The sample is stratified on three criteria. The first stratum is the targeted seven disciplines. The second stratum is the three EC2000 adoption statuses (early: 1998-2000, required: 2001-2003, and deferred: 2004-2006). The third selection stratum is the programs and institutions that did and did not participate in the various NSF engineering coalitions during the 1990s. The sample is “disproportionate” because the team over-sampled the smaller disciplines (aerospace and industrial) to ensure an adequate number of responses for analysis. To round out the sample, four EC2000 pilot institutions (first reviewed in 1996 and 1997), and several Historically Black Colleges and Universities (HBCUs) and Hispanic Serving Institutions (HSIs) were added to ensure their representation in the study.

**Table 2 EC2000 Study Objects and Data Sources**

<table>
<thead>
<tr>
<th>Objects of Study</th>
<th>Sources of Information</th>
<th>ABET, ASEE, and IPEDs Databases</th>
<th>Dean Interviews</th>
<th>Chair Survey</th>
<th>Faculty Survey</th>
<th>Senior Survey</th>
<th>Alumni Survey</th>
<th>Employer Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Outcomes &amp; Educational Experiences</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curriculum &amp; Instruction</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty Culture</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admin. Policy &amp; Organizational Influences</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Institutional &amp; Program Information</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

The final sample included 203 programs at 40 institutions, distributed as shown in Table 3. The distribution of programs at sample institutions is remarkably similar to those in the larger population. Both the number of undergraduate degrees awarded and the number of faculty in each engineering discipline are within 3 percentage points of the population totals. The percentage of undergraduate degrees awarded by public and private institutions also aligns with the distribution in the population from which the sample is drawn; and the profile of small, medium, and large programs in the sample roughly matches the actual program size profiles in each of the seven disciplines.
### Table 3  Sample Characteristics: Engineering Discipline by EC2000 Adoption Status

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Adoption Status</th>
<th>Sample (N = 985)</th>
<th>Population Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early</td>
<td>On-Time</td>
<td>Deferred</td>
</tr>
<tr>
<td>Aerospace</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Chemical</td>
<td>9</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Civil</td>
<td>12</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Computer</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Electrical</td>
<td>12</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Industrial</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Mechanical</td>
<td>12</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Total Programs</td>
<td>69</td>
<td>68</td>
<td>48</td>
</tr>
<tr>
<td>Total Institutions</td>
<td>13</td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>

Source: ASEE Profiles of Engineering and Engineering Technology Colleges Data Management System, 2001

The sample includes 16 institutions that participated in an NSF Coalition, three HBCUs, and seven HSIs. Based on the Carnegie Classification of institutional types, the sample includes 27 Research-Extensive institutions, three Research–Intensive institutions, six Masters institutions, and four institutions categorized as Baccalaureate or Engineering and Technical institutions. There are 24 public and 16 private institutions in the sample. At the time this paper was submitted, 34 of the 40 participating institutions had agreed to have their names associated with the study. See Appendix B for this list of institutions (as of March 17, 2004).

**Instrument Development:** The EC2000 Study requires the development of five new survey instruments (one each for program chairs, faculty, graduating seniors, alumni, and employers) and a telephone protocol for the interview with deans of participating institutions. To date, three survey instruments (program chairs, faculty, and seniors) have been developed and put into the field. Development of the alumni and employer surveys, and the deans’ interview protocol, was underway at the time this paper was submitted.

A key goal of the survey development process is to develop psychometrically-sound measures of the 11 a-k learning outcomes that are specified in Criterion 3 of the EC2000 accreditation standards:

- 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.

An additional learning outcome, “ability to manage a project,” is included in the faculty, student, and alumni because it is frequently mentioned in the literature on engineering education.

Work on the survey instruments began with a review of the literature on teaching and learning in engineering. The research team identified articles that described or reported on assessment practices, course and program redesign, and changes in teaching practices as a result of preparation for accreditation under EC2000. This was supplemented by a review of the general higher education literature for discussions and studies of the impact of assessment, changes in instructional practice, curricular change, and the role of faculty culture in college and university contexts. These reviews led to 1) the development of a set of course and program level changes that might be expected in engineering programs preparing for an EC2000 review, and 2) identification of potential survey items that might be used to assess the a-k learning outcomes. The team also examined self-study documents from selected engineering programs for survey instruments designed to measure changes in program curricula, faculty teaching, and student learning. The team gratefully acknowledges the inspirations for several survey items, including items on curriculum planning and continuous improvement, lifelong learning and learning about global and societal contexts, instructional practices, as well as student educational experiences in classes and academic programs.

The members of the EC2000 National Advisory Board reviewed drafts of three of the five survey instruments at its first meeting in October 2003. In addition, many additional engineers provided input during the survey development process. As the team developed the faculty, program chair, and student surveys, the members met several times with volunteers from Penn State’s College of Engineering to discuss specific survey items as well as general approaches. A draft of the faculty survey was piloted in a focus group with a small number of participants at the 2003 Harvey Mudd Design Workshop. After revisions based on the Mudd focus group were made, the revised faculty survey was piloted with Penn State engineering faculty. In August 2003, the Dean of the College of Engineering at Penn State sent an email invitation to participate in the pilot study to all engineering faculty at Penn State. Nearly 100 PSU engineering faculty completed this web-based version of the survey and answered a set of questions that asked for specific information and reactions to the instrument. Both the focus group and pilot provided valuable feedback on instrument format (response options, length, ability to answer particular questions, etc) and suggested new survey items. Contact persons at institutions participating in the study also offered valuable suggestions about the draft surveys that they examined in the process of determining whether their institutions would participate in the research effort.

In addition to development of the faculty and program chair surveys in spring 2003, the research team developed a set of scales to measure each of the 11 a-k learning outcomes. As a result of the literature review, the team assembled over a hundred different articles, conference papers, and self-study documents that described strategies, methods, and instruments for assessing student learning. This work generated a list of 286 self-report items, 20-40 for each of the 11 outcomes. Next, the team members reduced this list of items by combining, rewording, editing, or discarding items in the item bank. Through this iterative process, the research team substantially cut the list of items. The team then invited a small group of Penn State engineers,
from a number of the disciplines represented in the study, to evaluate the usefulness of the items. These sessions resulted in further revisions of the items and wording. Eventually, the research team and engineering experts pared the list to roughly 40 survey questions that could be used to measure the 11 outcomes.

In August 2003, the research team pilot tested the a-k measures with Penn State engineering students who had completed seven or more semesters of undergraduate work. The team sent an email to more than 1700 students, inviting them to complete a web-based survey. Nearly 370 students responded to this request. Although the sample of students was drawn from a single institution, and was therefore not representative of the population of engineering undergraduates, the large number of subjects made it possible to conduct the factor analysis.

The factor analysis also revealed that the items in the a-k scales could be reduced to four factors. A reduced factor solution is useful when it is not reasonable to expect survey respondents to be able to comment knowledgeably on each of the 11 outcomes, as in the case of requests to faculty and employers for retrospective assessments of pre-EC2000 graduates’ capabilities. The four-factor solution includes the following sets of skills: (1) fundamental engineering skills, design and practice; (2) teamwork and interpersonal skills; (3) contemporary issues, ethics, and professionalism; and (4) lifelong learning. The research team added a fifth item, “ability to use engineering, math, science, and technical skills,” to ensure that assessments of pre-EC2000 student learning would include a measure of technical skills. This will allow the research team to conduct comparative analyses to determine if the increased emphasis on professional skills in the a-k criteria has had any impact on graduates’ technical abilities.

The following five items are included in the faculty and employer survey instruments to collect retrospective assessments of the skills of pre-EC2000 graduates.

- Ability to use engineering, math, science, and technical skills
- Ability to apply problem-solving skills
- Ability to communicate and work in teams
- Ability to understand the organizational, cultural, and environmental contexts and constraints of engineering practice, design, and research
- Ability to continue to learn, grow, and adapt as technology and society evolve in unpredictable directions.

The factor analysis will be re-run on the final sample to determine if the results are consistent with the pilot.

The Program/Faculty component of the EC2000 Study assesses teaching and learning in engineering programs, examining three sets of potential influences on student learning – program curricula, teaching methods, and faculty culture, which, for the purposes of this study, includes involvement continuous improvement activities (e.g., curriculum planning, assessment of student learning), and perspectives on institutional reward systems. Two surveys, one for engineering program chairs, and another for faculty, are used to gather this information.

The survey of Engineering Program Changes collects program-level information from engineering program chairs. The first section of the survey instrument focuses on changes over time in the emphasis on curricular topics consistent with the EC2000 criteria (such as
interpersonal and group communication, teamwork, knowledge of contemporary issues, lifelong learning, etc.). Program chairs are asked to estimate the influence of ABET’s EC2000 on any changes they report. Respondents are also asked to estimate the level of faculty support for assessment and continuous improvement efforts, and to describe changes in the use of assessment data for different purposes (for example, internal budget allocations, ABET accreditation, and continuous improvement efforts). Finally, the instrument collects information on changes in program resources over time, and the program’s response to its last EC2000 accreditation review, if applicable.

The survey of Faculty Teaching and Student Learning collects information from tenure-track faculty in engineering programs. The first section of the survey focuses on a course that the faculty member regularly teaches, capturing changes in curricular emphases and the use of active learning strategies over time in that focal course. Faculty respondents are also asked to estimate the influence of the EC2000 accreditation standards on the changes they have made in their focal course, and to report on the effects of those course changes on student learning as defined by EC2000 Criteria 3, a-k. Next, faculty are asked to assess graduating seniors in their programs on the same a-k competencies, and to compare the learning of their current seniors with that of their pre-EC2000 alumni counterparts. Finally, respondents provide information on their engagement in assessment and professional development activities, as well as their perceptions of their program culture (e.g. promotion and tenure policies, curriculum planning practices).

Whereas program chairs and faculty are in the best position to report on curriculum and instruction and the culture of engineering programs, deans have a broader, institutional-level perspective on the influence of EC2000. Telephone interviews, using a semi-structured interview protocol, will gather contextual information, such as insights into available resources, unit and institutional priorities, and other engineering initiatives that can influence an institution’s response to EC2000 from the deans of institutions participating in the EC2000 Study.

Surveys of graduating seniors and alumni are critical complements to the surveys of program chairs and faculty because these target populations afford a student perspective on engineering program curricula and instruction. Graduating seniors and alumni are able to describe their educational experiences in engineering major programs, and to assess their learning as it relates to the a-k outcomes, thus providing additional evidence of the impact of EC2000. The main focus of the survey of Graduating Seniors in Engineering Programs is the assessment of student learning. The instrument first collects personal background and academic information. It then asks students’ to assess their learning on a set of scales designed to measure each of the 11 a-k learning outcomes (described earlier in this paper). In addition, students are asked to self-assess their thinking/analytical and project management skills. This information is contextualized through questions that ask students to describe their educational experiences inside and outside the classroom and in their programs. Finally, respondents are asked to report future plans.

The EC2000 Study design requires a comparison of the learning outcomes of current graduating seniors and those of pre-EC2000 alumni to determine if there are significant differences in preparation of students for engineering careers before and after the implementation of EC2000. An alumni survey that parallels the survey of graduating seniors was in development at the time this paper was submitted.
The Employer component of the study, which provides yet another perspective of the quality of graduates’ preparation for careers in engineering, is also in development. Employers who can comment knowledgeably about the abilities of new hires in at least one of the seven focal disciplines will be asked to provide assessments of recent new hires and of new hires educated in pre-EC2000 programs. These assessments of engineering graduates’ abilities will be compared with those offered by faculty, students, and alumni to provide a 360-degree evaluation of student learning.

Together, these data sources will provide information about the learning outcomes and educational experiences of engineering graduates from different and distinctive perspectives. Each data source has its strengths and weaknesses. Because over-reliance on a single source of evidence can exacerbate measurement error, the EC2000 Study design utilizes multiple sources of evidence to determine the impact of the new accreditation criteria on the key variables of student learning (a-k). This design should yield more reliable and valid assessments than single-source approaches.

Survey Administration: The Survey Research Center (SRC) at Penn State University is handling survey administration, data collection, and data management for the EC2000 Study. Participants in the Study are given the option of answering a paper survey and returning it in a postage-paid envelope or answering a web-based version of the study on a secure server. Using text provided by the research team, SRC produces and sends all survey packets, reminder postcards, and email messages. The survey packets sent by first class mail included a cover letter explaining the purpose of the study, a statement of implied consent, and the appropriate survey instrument. The letter of invitation included a web address where respondents could access the web-based version of the survey. Reminder postcards and/or emails, which include instructions for completing the web-based survey, were mailed to non-respondents. Before data files are provided to the researchers at the Center for the Study of Higher Education for analysis, all identifying information is stripped from the files so that all responses are strictly anonymous.

Planned Analyses

All analyses of the EC2000 Study data will be conducted by engineering discipline. The EC2000 Study will not evaluate individuals, programs, or institutions. Three kinds of analyses will be conducted.

First, the research team will analyze student learning and students’ educational experiences by discipline, providing baseline profiles of the seven engineering disciplines examined in the study. For example, the research team will generate descriptive statistics for each discipline on

- program and course-level changes in curricular topics emphasized by in the past decade, and the influences on these changes;
- changes in faculty use of different instructional methods and the influences on those changes;
- ABET’s influence on changes in program curriculum components; and
- changes in program emphasis on teaching in hiring, promotion, salary decisions
- assessments of student learning on the a-k outcomes for current seniors and pre-EC2000 alumni
A key component of the analysis will determine whether there are significant differences in students’ educational experiences and student learning outcomes among the seven disciplines using a Multiple Analysis of Variance (MANOVA). Average ratings by discipline will be reported.

Multivariate analyses will ascertain the extent to which particular educational experiences or program characteristics contribute to different levels of achievement on the a-k learning outcomes. For example, the research teams plans to examine the extent to which particular instructional approaches, such as the use of groups and/or case studies and real world examples in class, influence student learning outcomes such as the ability to work in multidisciplinary teams. The research team will also examine the extent to which continuous improvement practices (assessment and/or curriculum revision practices) are associated with higher levels of student learning. These multivariate analyses will take into account differences in institutional types (i.e., differences in the size, mission, and institutional wealth of participating colleges and universities), as well as institutions’ cohort status (whether a program stood for accreditation under EC2000 early, on-time, or deferred their EC2000 visit).

**Putting the Findings of the EC2000 Study to Work**

The EC2000 Study was designed to meet several needs. First, the study will provide a comprehensive assessment of the impact of ABET’s new accreditation standards that can be used for ABET’s own continuous improvement efforts. Second, the study will produce baseline measures of student learning against which subsequent measures can be compared. Third, the study design and instruments constitute an evaluation model that can be replicated in the future when student learning outcomes, employers’ assessment of graduates, and institutional and program influences are again matters of concern. In addition to serving as an evaluation template for ABET, the study design and instruments suggest a model that other professional and/or accreditation agencies can adopt and adapt.

By providing generalizable information on the relationships among engineering program characteristics (e.g., curricula, teaching methods) and student learning, the EC2000 Study may assist engineering programs as they plan educational innovations. The institutions that joined the research effort will also benefit from their participation. The research team will supply each participating program with the results of the faculty, senior, alumni and employer responses (when the N is at least 10) so that these can be used in ongoing assessment efforts. The team will also generate comparisons that will enable programs to compare their results to those of the larger disciplinary population. To compensate participating institutions for providing access to their students, alumni, faculty, and program chairs, the research team provided a $1000 reimbursement for costs associated with generating contact information files for use in the EC2000 Study.

Finally, the EC2000 Study team will conduct analyses of the data that will be of interest to higher education practitioners and scholars both inside and outside the field of engineering. For example, the EC2000 Study will be the first national study of the impact of an outcomes-based professional accreditation process and thus will be of great interest to accreditors, scholars, and
higher education administrators who are concerned with the ability of such accreditation systems to improve the quality of student learning in higher education.

Bibliographic Information


Biographical Information

Dr. LISA R. LATTUCA is Project Director and Co-Principal Investigator for the EC2000 Study. An assistant professor and research associate in the Center for the Study of Higher Education at Penn State University, Dr. Lattuca’s areas of expertise include curriculum, instruction, and faculty work related to teaching and learning.

Dr. J. FREDERICKS VOLKWEIN, professor of education and senior scientist in the Center for the Study of Higher Education, is also a Co-PI for the EC2000 Study. He has produced more than 100 research reports, conference papers, journal articles, and book reviews. His scholarly work focuses on topics related to organizational effectiveness.

Dr. PATRICK T. TERENZINI is Co-Principal Investigator of the EC2000 Study. A professor and senior scientist in the Center for the Study of Higher Education at Penn State, he has published over 90 articles in refereed journals and made numerous invited presentations at national conferences. He was a co-principal investigator for the ECSEL evaluation.

Dr. LINDA C. STRAUSS, senior project associate for the EC2000 Study, includes program evaluation, research methods, and statistics among her areas of expertise. Dr. Strauss is the author of several research articles and chapters on organizational effectiveness and ethnic identity.

JAVZAN SUKHBAATAR, a graduate research assistant in the doctoral program in Higher Education at Penn State, supports the EC2000 Study with experience in accreditation and program evaluation gained in his native country of Mongolia.
Appendix A

National Advisory Board for EC2000 Study

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Appendix B

Public List of Participating Institutions
(Permission to Use Name as of 3.17.04)*

California State Polytechnic University at Pomona
California State University Sacramento
Case Western Reserve University
Clemson University
Cornell University
Georgia Institute of Technology
Howard University
Iowa State University
Lehigh University
Marquette University
Massachusetts Institute of Technology
North Carolina A&T State University
Princeton University
Ohio State University
South Dakota School of Mines and Technology
Syracuse University
Texas A&M University
Tri-State University
Tuskegee University
Union College
United States Military Academy
University of California at Los Angeles
University of Florida
University of Illinois at Chicago
University of Michigan
University of Missouri - Columbia
University of Notre Dame
University of the Pacific
University of Texas at Arlington
University of Texas at Austin
Virginia Polytechnic University
Western Michigan University
Worcester Polytechnic Institute
Youngstown State University

* As of March 17, 2004, 34 of the 40 institutions participating in the EC2000 Study had given permission to associate their names with the study. Responses from 6 institutions were pending.