



## **ENGINEERING CHANGE: A Study of the Impact of *EC2000***

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# ENGINEERING CHANGE: A Study of the Impact of EC2000

## Project Description

Are the engineers who complete undergraduate programs under ABET's EC2000 accreditation criteria and processes better prepared for careers in engineering than those who graduated before implementation of EC2000? This document provides an overview of the research design, sampling plan, and data collection procedures for the *Engineering Change (EC) Project* – a three-year study that examines the impact of ABET's EC2000 on engineering education. The project brings multiple sources of evidence to bear on this question and will provide an evaluation model that can be replicated when ABET again evaluates the impact of its accreditation standards on student learning at some future time.

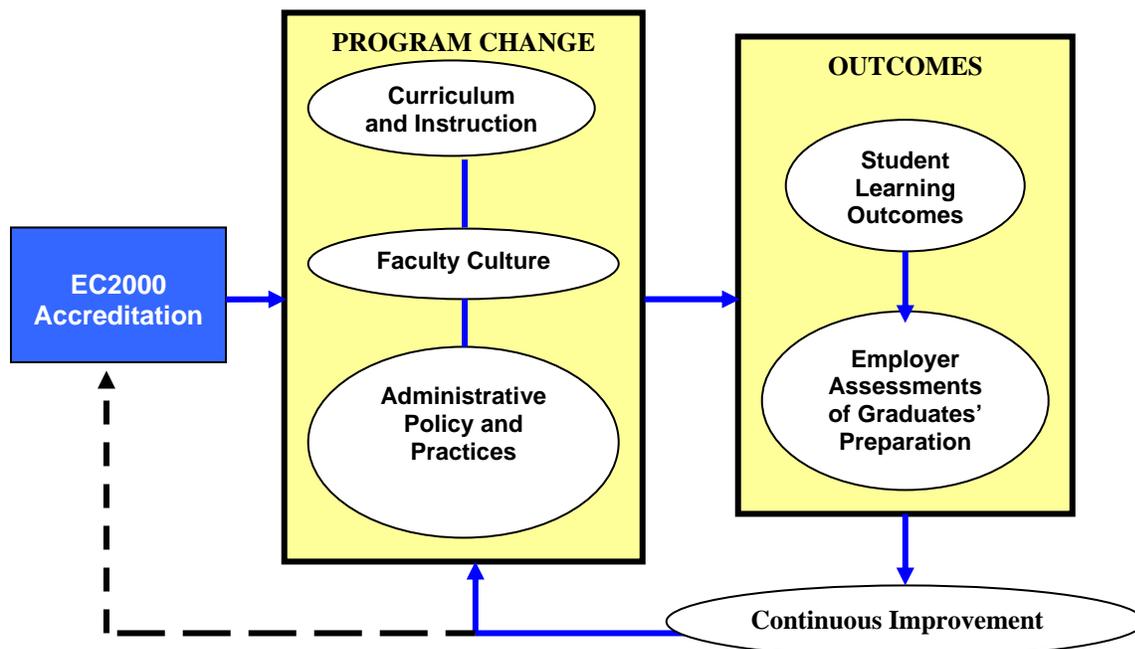
## Conceptual Framework for the Study

The Project assumes that if EC2000 has been effective, evidence of change in ABET-accredited programs will be linked to changes in engineering education outcomes. The primary focus of the EC2000 Study, thus, is on student outcomes. Compared to engineers prepared under previous guidelines, engineers educated in EC2000-accredited programs should exhibit higher levels of achievement on the 11 learning outcomes identified in the accreditation standards, Criterion 3.a-k. The EC2000 Study also investigates curricular modifications and instructional practices, institutional policies, and faculty cultures and attitudes that may, in turn, have affected student learning. Thus, 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?

The diagram shown in Figure 1 portrays the hypothesized relationships among the new EC2000 accreditation standards, engineering programs, and student (and alumni) learning outcomes.

**Figure 1. Conceptual Framework**



## Scope and Design of the Study

The EC2000 study is national in scope, aimed at accredited engineering programs in selected fields within a representative sample of institutions, and designed to compare pre-EC2000 and post-EC2000 information. The EC2000 Study 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).

In each discipline, programs are grouped into one of three categories based on when they were first reviewed under the EC2000 process – early (had the option of review under the old guidelines), required (mandatory review under EC2000), and deferred (had the option to undergo the EC2000 review but elected to defer until the next cycle). We also distinguish between those that did and did not participate in one of the various NSF Engineering Coalitions.

The project team selected programs for participation in the study based on a two-stage, disproportionate, stratified random sample with a 7x3x2 design. Randomization ensured that each institution in our population had an equal chance of having its programs selected. We also stratified the sample based 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 we over-sampled the smaller disciplines (aerospace and industrial) to ensure an adequate number of responses for analysis. To round out the sample, we added four EC2000 pilot institutions (first reviewed in 1996 and 1997), and we added several Historically Black Colleges and Universities and Hispanic Serving Institutions in order to ensure their representation in the study.

Pending agreements from the sample institutions to participate in the study, the sample now includes 207 programs at 41 institutions, distributed as shown in Table 1. 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 1. Sample Characteristics: Engineering Discipline by EC2000 Adoption Status**

Discipline	Adoption Status				Sample		Population (N = 985)
	Early	Required	Deferred	Pilot	n	Percent	Percent
Aerospace	8	5	5	1	19	9%	5%
Chemical	9	9	9	3	30	14	14
Civil	12	11	9	4	36	17	20
Computer	8	6	6	0	20	9	6
Electrical	12	12	12	4	40	20	24
Industrial	8	7	6	2	23	11	9
Mechanical	12	12	12	4	40	20	22
<b>Total Programs</b>	<b>69</b>	<b>62</b>	<b>59</b>	<b>18</b>	<b>208</b>	<b>100%</b>	<b>100%</b>
<b>Total Institutions</b>	<b>13</b>	<b>12</b>	<b>12</b>	<b>4</b>	<b>41</b>	<b>N/A</b>	<b>N/A</b>

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

**Data Sources:** The EC2000 Study relies upon multiple sources of information, including existing data and original data to be collected during the course of the study.

**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.

**New Information to be collected:**

- **Survey of Graduating Seniors in engineering programs:** In 2003-04, more than 9,000 seniors will be asked to assess their educational experiences and preparation in each of the 11 areas identified in EC2000 Accreditation Criterion 3.a-k.
- **Survey of Alumni/ae of engineering programs:** More than 9,000 graduates of pre-EC2000 programs will be asked to assess their educational experiences and preparation in each of the 11 areas identified in Criterion 3.a-k.
- **Survey of Engineering Faculty:** Approximately 2,000 faculty will be asked about changes in their courses, teaching practices, and professional activities over the past ten years, as well as about their perception of changes in student learning over that time period.
- **Survey of Program Chairs:** Almost 200 program chairs will be asked to describe changes in program policies, curricula, resources, facilities, and faculty activities in the past ten years. They will also be asked about changes in student learning attributable to program changes.
- **Telephone interviews with Deans:** Deans will be asked about the engineering school and institutional context influencing changes in curricula, programs, policies, and student learning during the past decade.
- **Telephone interviews with Engineering Employers:** Employers will be asked to assess changes, if any, they have seen in engineering graduates' abilities and capacities since the inauguration of EC2000.

**Data Collection Procedures:** There is little existing data that can be used to assess the specific knowledge and skills of engineering undergraduates and alumni nationwide. As a result, the EC2000 Study relies heavily on new data to be collected through paper and Web-based surveys and telephone interviews. We are developing four paper and Web-based survey instruments (one each for seniors in engineering programs, alumni, faculty, and program chairs) and two telephone interview protocols (for deans and employers).

Table 2 demonstrates how each of these data sources contributes to the study. Each object of study benefits from multiple sources of evidence. In all cases, data collection procedures are being designed to permit analysis for each of the seven engineering disciplines. Because the ultimate test of EC2000 is its effect on student learning outcomes, the assessment of a-k outcomes among students and alumni is the central component of the EC2000 Study.

**Table 2. Components of the Research Plan**

Sources of Information Objects of Study	ABET, ASEE, and IPEDs Databases	Dean Interviews	Chair Survey	Faculty Survey	Senior Survey	Alumni Survey	Employer Survey
Student Outcomes & Educational Experiences			X	X	X	X	X
Curriculum & Instruction		X	X	X	X	X	
Faculty Culture		X	X	X			
Admin. Policy & Organizational Influences		X	X	X			
Institutional & Program Information	X	X	X	X			

With the exception of the deans’ interview protocol, all instruments will request information on student achievement, particularly students’ abilities on the 11 competencies identified in ABET’s EC2000 Criterion 3.a-k (listed below):

- 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.

In addition to assessments of student preparation on these 11 learning outcomes, faculty, program chairs, students, and alumni will be asked about educational experiences that may have influenced student performance on these outcomes.

**Instrument Development:** Early in the project, we reviewed the engineering and higher education literature to identify relevant research, instruments, and measures. We also examined an array of self-study documents from selected engineering programs searching for survey instruments that tap the Criterion 3.a-k outcomes. Using this information, we generated a list of approximately 300 a-k items, including items designed by the EC2000 Study team. This list was reduced by more than 90% through a series of internal discussions and sessions with a small group of Penn State engineers who evaluated the items and provided suggestions for further revisions.

The a-k scales designed by the EC2000 Study team will be incorporated into the student and alumni surveys. The original ABET a-k criteria will be incorporated into the faculty, program chair, and employer surveys. In summer 2003, we pilot tested the faculty, and a-k scales on student surveys with Penn State faculty and students.

The timeline for data collection is:

<b>Population:</b>	<b>Data Collection Target</b>
Survey pilot testing	Summer 2003
Deans, Program Chairs, & Faculty	Fall 2003
Seniors graduating in 2003-04	Spring 2004
1994 Graduates	Spring 2004
Employers	Spring 2004

The EC2000 Study will provide ABET with a comprehensive assessment of the impact of its new accreditation standards, as well as an evaluation model that can be replicated in the future when evaluation of student learning outcomes, employers' assessment of graduates, and institutional and program influences are matters of concern. This evaluation template will also provide a model that other professional and/or accreditation associations can adopt and adapt.

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### **EC2000 Project Team**

The three principal investigators, all faculty members in the Center for the Study of Higher Education at Penn State University, bring a wealth of methodological and topical experience to the project. The Co-PIs are

- Dr. Lisa R. Lattuca, Project Director
- Dr. Patrick T. Terenzini
- Dr. J. Fredericks Volkwein

In addition to their expertise in quantitative and qualitative methods of data collection and analysis, the group brings national reputations in the areas of postsecondary curriculum and instruction (Lattuca), assessment of college student learning outcomes (Terenzini), and institutional research and policy issues (Volkwein). Dr. Terenzini's scholarly study for the ECSEL Coalition provides the team with substantive knowledge of engineering education. This expertise has been supplemented by a consulting relationship with Drs. Carol Colbeck and James Fairweather who also have experience in assessing engineering education in general, and ECSEL in particular.

Dr. Linda Strauss, senior project associate, brings experience in program evaluation, research methods, and statistics. Javzan Sukhbaatar (MBA), a graduate research assistant, supports the project with experience in accreditation and program evaluation in his native country of Mongolia. Another graduate research assistant, Vicki Baker (MBA) has experience as a safety engineer and executive education administrator. Suzanne Bienert (M.Ed. in Higher Education) supports the team with skills in project management, Web page design, and document development and editing.