A Longitudinal Study of the ABET Outcomes-Based Accreditation Model

INQAAHE Madrid 2011
Outline of the Presentation

• Context
  – What was the *Impetus for Change*?
  – What was the *Change*?
  – What is the Impact - *The Longitudinal Study*?

• Key findings of the *Longitudinal Study*
  – Program Changes
  – Student Experiences
  – Student Learning Outcomes

• Conclusions and Implications
  – The good and the opportunities for improvement
Impetus for Change

Circa 1990…

• **Industry** seeks graduates with quality technical AND professional skills, but dense accreditation criteria leave programs no room cover both.

• **Deans** attempt to innovate engineering education to meet the needs of industry, but face brick wall in prescriptive accreditation criteria.

• **ABET** adopts new leadership philosophy and strives to ensure quality AND stimulate innovation in engineering education.
New Philosophy

- Institutions and programs define mission and objectives to meet the needs of their constituents – enables program differentiation.

- Emphasis on outcomes – *What students learn, less on what they were taught.*

- Programs demonstrate how criteria and educational objectives are being met

- Practice of Continuous Quality Improvement
  - Input from Constituencies
  - Process focus
  - Outcomes and Assessment Linked to Objectives
Basic Level Criteria

1. Students
2. Program Educational Objectives
3. Program Outcomes and Assessment
4. Professional Component
5. Faculty
6. Facilities
7. Institutional Support & Financial Resources
8. Program Criteria
Student Learning Outcomes

EC2000: Criterion 3, a-k

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

→ A twelfth outcome, “ability to manage a project,” was added to the research study because it is frequently mentioned in the literature on engineering education
Tracking Student Learning Outcomes

- 1994: Benchmark (Pre-EC2000)
- 2001: EC2000 Mandatory
- 2004: Engineering Change Study (1st Post-EC2000 Data Point)
Key Questions

1. What impact, if any, has EC2000 had on graduating seniors’ preparation to enter the engineering profession?

2. What impact, if any, has EC2000 had on practices that may be related to changes in student preparation?
The Longitudinal Study
Studying the Impact of EC2000

EC2000
Outcomes-Based

PROGRAM CHANGES
Curriculum & Instruction
Faculty Culture
Policies & Practices

STUDENT EXPERIENCES
In-Class
Out-of-Class

OUTCOMES
Student Learning (3.a-k)
Employer Ratings

Continuous Quality Improvement
### Data Sources and Response Rates

<table>
<thead>
<tr>
<th>Data Sources</th>
<th>Target Population</th>
<th>Number of Responses</th>
<th>Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programs</td>
<td>203</td>
<td>147</td>
<td>72%</td>
</tr>
<tr>
<td>Faculty</td>
<td>2,971</td>
<td>1,243</td>
<td>42%</td>
</tr>
<tr>
<td>Deans</td>
<td>40</td>
<td>40+</td>
<td>98%</td>
</tr>
<tr>
<td>1994 Graduates</td>
<td>13,054</td>
<td>5,494</td>
<td>42%</td>
</tr>
<tr>
<td>(Pre-)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004 Graduates</td>
<td>12,921</td>
<td>4,330</td>
<td>34%</td>
</tr>
<tr>
<td>(Post-)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employers</td>
<td>unknown</td>
<td>1,622</td>
<td>N/A</td>
</tr>
<tr>
<td>Participating Institutions: Doctoral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arizona State University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case Western</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clemson University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cornell University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Georgia Tech</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Howard University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois Institute of Tech.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iowa State University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lehigh University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marquette University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio State University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Princeton University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purdue University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syracuse University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temple University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas A&amp;M University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Arkansas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UCLA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Florida</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Illinois, Chicago</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Michigan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Missouri, Columbia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Notre Dame</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Texas, Arlington</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of Texas, Austin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University of the Pacific</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia Tech</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Michigan University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worcester Polytechnic Institute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participating Institutions: Master’s and Bachelor’s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Master’s</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal. Polytechnic, Pomona</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal. State, Sacramento</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embry-Riddle, Daytona</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Carolina A &amp; T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuskegee University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youngstown State Univ.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bachelor’s and Others</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Dakota School of Mines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tri-State University</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Union College</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States Military Academy</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Longitudinal Study
Studying the Impact of EC2000

EC2000 Outcomes-Based

PROGRAM CHANGES
- Curriculum & Instruction
- Faculty Culture
- Policies & Practices

STUDENT EXPERIENCES
- In-Class
- Out-of-Class

OUTCOMES
- Student Learning (3.a-k)
- Employer Ratings

Continuous Quality Improvement
Significant Findings: Curriculum and Instruction at Course Level

Faculty report:

• Increased emphasis on engineering tools, design, teamwork, and contemporary issues and contexts.
• Increased use of active learning methods.
• Greater increases in emphasis on teamwork, communication skills, and use of engineering tools.
• Faculty and chairs report little change in emphasis on basic math and science.
The Longitudinal Study
Studying the Impact of EC2000

EC2000 Outcomes-Based

PROGRAM CHANGES
- Curriculum & Instruction
- Faculty Culture
- Policies & Practices

STUDENT EXPERIENCES
- In-Class
- Out-of-Class

OUTCOMES
- Student Learning (3.a-k)
- Employer Ratings

Continuous Quality Improvement
Significant Findings: Faculty Culture

• More than 70% of program chairs indicate high levels of faculty support for continuous improvement.

• 88% of faculty report at least some personal effort in program assessment.

• 68% of faculty consider their level of effort in assessment to be “about right.”

• 20 - 25% of faculty say they have increased their personal efforts to improve their courses.
The Longitudinal Study
Studying the Impact of EC2000

**EC2000 Outcomes-Based**

**PROGRAM CHANGES**
- Curriculum & Instruction
- Faculty Culture
- Policies & Practices

**STUDENT EXPERIENCES**
- In-Class
- Out-of-Class

**OUTCOMES**
- Student Learning (3.a-k)
- Employer Ratings

Continuous Quality Improvement
Significant Findings: Students’ In- and Out-of-Class Experiences

Compared to 1994 graduates, 2004 graduates reported:

- Greater active engagement in their own learning
- More interaction with instructors
- More feedback from instructors
- More time spent in cooperative or internship experiences
- More international travel
- More involvement in engineering design competitions
- Greater emphasis on openness to new ideas and people
- Some uncertainty about changes in diversity climate.
The Longitudinal Study
Studying the Impact of EC2000

**EC2000**
Outcomes-Based

**PROGRAM CHANGES**
- Curriculum & Instruction
- Faculty Culture
- Policies & Practices

**STUDENT EXPERIENCES**
- In-Class
- Out-of-Class

**OUTCOMES**
- Student Learning (3.a-k)
- Employer Ratings

Continuous Quality Improvement
Math, Science, and Engineering Skills Cluster

<table>
<thead>
<tr>
<th></th>
<th>1994 Graduates (Pre-)</th>
<th>2004 Graduates (Post-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying Math and Science (Criterion 3.a)</td>
<td>4.02</td>
<td>4.07***</td>
</tr>
<tr>
<td>Experimental Skills (Criterion 3.b)</td>
<td>3.73</td>
<td>3.91***</td>
</tr>
<tr>
<td>Applying Engineering Skills (Criterion 3.k)</td>
<td>3.56</td>
<td>3.95***</td>
</tr>
</tbody>
</table>

*** p<.001

**Criterion 3.a**

**Criterion 3.b**

**Criterion 3.k**
Project Skills Cluster

Design and Problem-Solving Skills (Criterion 3.c,e)  
- 1994 Graduates: 3.67  
- 2004 Graduates: 3.89***

Communication Skills  (Criterion 3.g)  
- 1994 Graduates: 3.74  
- 2004 Graduates: 3.97***

Group Skills  (Criterion 3.d)  
- 1994 Graduates: 3.83  
- 2004 Graduates: 4.22***

*** p<.001
Contexts and Professionalism Cluster

Adjusted Mean Score

1994 Graduates (Pre-)  2004 Graduates (Post-)

Societal and Global Issues (Criterion 3.h,j) 3.65***
Ethics and Professionalism (Criterion 3.f) 4.04***
Life-long Learning (Criterion 3.i) 3.49***

*** p<.001
Deans’ Comments

• Interviews with Deans of participating institutions resonated with many of the findings.
  
  – EC2000 credited with promoting good educational planning processes.
  
  – EC2000 “enabled” change.
  
  – Deans comment “…ABET is one of several important influences on curriculum, teaching, and learning in engineering programs.”
Deans’ Comments

• Deans rarely reported that EC2000 changed their priorities or direction.
• A few worried EC2000 might have misdirected faculty efforts.
• Many reported EC2000 increased administrative and/or faculty workloads.
• Typically, Deans reallocated existing funds for EC2000-related activities.
• Few reported EC2000 affected promotion and tenure policies.
The Longitudinal Study
Studying the Impact of EC2000

EC2000
Outcomes-Based

PROGRAM CHANGES
- Curriculum & Instruction
- Faculty Culture
- Policies & Practices

STUDENT EXPERIENCES
- In-Class
- Out-of-Class

OUTCOMES
- Student Learning (3.a-k)
- Employer Ratings

Continuous Quality Improvement
The Employer Respondents
Diversity

• **Industry Sectors:**
  – Respondents represent all 19 industry sectors
  – About half work in companies engaged in manufacturing or providing scientific and technical services.

• **Geographic Spread:**
  – Respondents represent all US states, territories, and 24 foreign countries.

• **Company Sizes:**
  - Less than 50 employees 25%
  - 50-499 39%
  - 500-3,000 24%
  - More than 3,000 13%
Significant Findings: Employers

• Greatest increases seen in teamwork and communication skills and in life-long learning.

• About 1 of 4 employers report decreases in problem-solving skills and understanding of social and environmental contexts.

• Large national employers are more positive in their Pre- and Post-EC2000 ratings than are smaller local and regional employers.

• Majority of employers rate nearly all the a-k criteria as highly important or essential for new hires.
Conclusions and Implications

• America’s engineers are measurably better prepared than their peers of a decade ago.

• Some differences are substantial:
  – Societal and Global Issues
  – Applying Engineering Skills
  – Group Skills
  – Ethics and Professionalism

• Reported decreases in technical skills areas from some faculty and employers may suggest where more work needs to be done.
Conclusions and Implications

- 25% of the employers also report decreases in problem-solving skills…but 75% report recent graduates adequately or well-prepared in problem-solving.

- Fewer employers than faculty report decreases in abilities to apply math, science, and technical skills.

- More than 90% report recent graduates adequately or well-prepared to apply math, science and technical skills.
Thank you on Behalf of