Engineering Education Research Demonstrates Employer Support for Revised Engineering Education Practices and Accreditation Standards

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Accreditation of engineering programs shifted
• From looking at what is taught to what is learned, and
• From an exclusive focus on technical skills to a balanced focus on technical and professional skills.

The new accreditation regime is called EC2000.

As a result of the shifts, employers, particularly at larger, national firms are more satisfied with the graduates produced.
Responding to the concerns of Engineering Employers and Engineering School Deans, the Accrediting Board of Engineering and Technology (ABET) developed, pilot-tested, and implemented a new set of accreditation standards (EC2000) aimed at producing engineers who are equipped with strong technical \textit{and} professional skills.

Was this change in accreditation standards successful?

The Evidence from our study is \textbf{YES}!
Study Overview

We analyzed 1,622 survey responses from a diverse array of employers from seven engineering fields (aerospace, chemical, civil, computer, electrical, industrial, and mechanical). The responding employers represent richly variable geographic locations, industry types, company sizes, organizational ranks, educational preparation, and evaluation experience. Despite their diversity, employers are in substantial agreement about the importance of the 3a-k accreditation criteria and the preparation of new engineers, even across engineering disciplines.

An Executive Summary of the EC2000 Study is available at: [http://www.abet.org/papers.shtml](http://www.abet.org/papers.shtml) and a complete copy of the full study may be purchased from ABET, Inc. through this web address.
Big Picture Employer Findings:

• Over 70% of employers rate all the EC2000 outcomes as highly important or essential.

• More than 80% of employers rate new engineers as adequately prepared or well-prepared in Scientific, Technical, Adaptive, and Problem-Solving engineering skills.

• 52%-86% of employers rate their new engineers as adequately to well-prepared in various professional knowledge and skill areas, such as teamwork, communicating, lifelong learning, understanding contexts & constraints.
Big Picture Employer Findings:

• More than half of the Employers report no change since EC2000, but others report the greatest improvements in teamwork and communication skills and in learning/adapting.

• Employers from larger companies that recruit nationally and hire the most engineers are more favorable in their judgments both of new engineers’ preparation and of the pre-post-EC2000 change than are employers from smaller companies that recruit locally and hire fewer employees. National employers also place more importance on the new EC2000 criteria.

• Employers are in substantial agreement. An extensive series of tests indicate only a handful of significant differences related to employers’ engineering field, industry sector, degree attainment, or geographic location.

Source: Penn State CSHE EC2000 report
Implications for Engineering Education

• The ABET emphasis on the EC2000 criteria are in substantial harmony with the views of employers; thus the new standards seem to be guiding engineering schools down the right track.

• Engineering programs and faculty need to give curricular priority to the areas that are rated most important by employers – engineering technical and design skills, effective communication, problem-solving, teamwork, and professional ethics.

• The Faculty appear to be seeing positive EC2000 changes at an earlier stage in the pipeline than the employers. Moreover, the Faculty see the entire range of the talent pool, including those who enter graduate school as well as those who enter the workforce.

• The large national employers who recruit from the top of the talent pool and who hire and evaluate the greatest number of new engineers each year, appear to see positive post-EC2000 changes that align with those of the faculty.
The 1,622 Employer Respondents Represent Diverse:

- Industry Sectors: All 19 industry sectors
- Geographic Spread: All US states & territories.
- Company Sizes:
  - Less than 50 employees: 25%
  - 50-499 employees: 39%
  - 500-3,000: 24%
  - More than 3,000: 13%
- Engineering Fields and Educational Backgrounds:
  - 55% hold masters or doctoral degrees
- Evaluation Experiences: --84% evaluate more than one new engineer per year.
Comparing National vs. Local Employers

<table>
<thead>
<tr>
<th></th>
<th>Smaller Local &amp; Regional Employers</th>
<th>Large National Employers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average preparation</td>
<td>2.07</td>
<td>2.10*</td>
</tr>
<tr>
<td>Average pre-post change</td>
<td>2.08</td>
<td>2.12**</td>
</tr>
<tr>
<td>Average 3a-k importance</td>
<td>3.73</td>
<td>3.86***</td>
</tr>
</tbody>
</table>

3-point scale: where 1 = “Inadequately Prepared” and 3 = “Well Prepared”

5-point scale: where 1 = “Unimportant” and 5 = “Essential”

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ABET EC2000 Criterion 3 Learning Outcomes for New Engineers

- 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

1,622 Employers Rate the Importance of the New EC2000 Outcomes

- g. Communicate effectively: 98% highly important or essential, 2% moderately important
- e. Engineering problem solving: 98% highly important or essential
- a. Apply math, science, engineering: 97% highly important or essential
- k. Use modern engineering tools: 97% highly important or essential
- d. Teamwork: 95% highly important or essential
- f. Understand professional and ethical responsibilities: 94% highly important or essential
- c. Design a system to meet needs: 92% highly important or essential
- i. Life-long learning: 90% highly important or essential
- b. Design/conduct experiments: 85% highly important or essential
- j. Knowledge of contemporary issues: 73% highly important or essential
- h. Engineering In global and social contexts: 70% highly important or essential

Legend:
- Blue: Moderately important
- Yellow: Highly important or Essential
For the Employer Ratings, we collapsed the eleven EC2000 Outcomes into five categories of Engineering Abilities/Skills

- Math, Science and Technical Skills
- Problem-Solving Skills
- Teamwork and Communications Skills
- Learning, Growing, Adapting
- Understanding Contexts and Constraints
Employers Rate the Preparation of New Engineers and the Pre-Post-EC2000 Changes

- **Use math, science, and technical skills**: Adequately or Well Prepared 92, Increase in Ability 18, Decrease in Ability 19
- **Learn, grow, and adapt**: Adequately or Well Prepared 86, Increase in Ability 28, Decrease in Ability 13
- **Apply problem-solving skills**: Adequately or Well Prepared 80, Increase in Ability 13, Decrease in Ability 26
- **Communicate and work in teams**: Adequately or Well Prepared 75, Increase in Ability 32, Decrease in Ability 17
- **Understand contexts/constraints**: Adequately or Well Prepared 52, Increase in Ability 15, Decrease in Ability 22

Legend:
- Blue: Adequately or Well Prepared
- Yellow: Increase in Ability
- Orange: Decrease in Ability
Comparing Employer and Faculty Ratings of EC2000 Changes in Graduates Abilities/Skills

<table>
<thead>
<tr>
<th>Skill</th>
<th>Employers</th>
<th>Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use Engineering, Math, Science, and Technical Skills</td>
<td>1.99***</td>
<td>1.90</td>
</tr>
<tr>
<td>Apply Problem-Solving Skills</td>
<td>1.86</td>
<td>2.02***</td>
</tr>
<tr>
<td>Communicate and Work in Teams</td>
<td>2.15</td>
<td>2.41***</td>
</tr>
<tr>
<td>Understand Organizational, Cultural, and Environmental Contexts</td>
<td>1.93</td>
<td>2.21***</td>
</tr>
<tr>
<td>Continue to Learn, Grow, and Adapt as Technology and Society Evolve</td>
<td>2.15</td>
<td>2.20***</td>
</tr>
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The Research Design for the EC2000 Study

EC2000

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

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

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

Continuous Improvement
The Hexagon of Assessment Information

1994 Graduates

1994 Graduates

Faculty, Chairs, Deans

2004 Graduates

Employers

National Databases

Project Data Bases

ABET & Engineering Professional Societies
Overview of Employer Data Collection

Employers
N = 1229
36 survey items (web only)

1994 Graduates/
Employers N = 393
36 survey items (paper or web)

Employer Characteristics And Assessments

Employer Demographics
- Engineering field
- Geographic region
- Organizational level
- Educational Attainment
- Industry type
- Company size
- Evaluation Experience

Assessments of New Hires on 5 Dimensions
- Math-Sci-Tech Skill
- Learn-Grow-Adapt
- Teamwork+Communications.
- Understand contexts/constraints

Pre-Post-EC2000 Assessments of Graduates (5 Dimensions)
- Today & 7-10 Years Ago

Importance of a-k Outcomes for New Hires
Professional Societies Assisting in Data Collection

- American Institute of Aeronautics and Astronautics (AIAA)
- American Institute of Chemical Engineers (AIChE)
- Institute of Electrical and Electronics Engineers, Inc. (IEEE)
- American Society of Civil Engineers (ASCE)
- American Society of Mechanical Engineers (ASME International)
- Institute of Industrial Engineers (IIE)