Engineering Education Research—Results/Impact

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ASEE-ERC
March 17, 2008
Outline

- What/Who is Involved with FEDS?
- Evaluation/Impact
- NSF Review
- Why Concerned?
- EEC Objectives
- Current Announcement
- Graduate Education Issues
Academic Competitiveness Council (2005)

Broad Federal Audiences

(a) 24 K-12 ($574 mil)
(b) 70 Post Secondary ($2.4 bil)
(c) 11 Informal ($137 mil)
Increase the number of undergraduates who enroll in and complete STEM degree programs and are prepared to enter STEM or STEM-related careers or advanced education.
Evaluation of Current Programs

(1) 115 total (1 study per $27 mil invested)

(2) 10 scientifically rigorous (15 underway)

(3) Example

The University of Michigan Undergraduate Research Opportunity Program created one-year research partnerships between faculty members and first- and second-year undergraduate students. Using a well-designed, randomized controlled trial, the investigators found that UROP produced a 25 percent decrease in the number of students leaving the university prior to graduation, as compared to the control group.
# Investment Timeline

**1980**
- National Science Board Homer Neal Report
- Presidential Young Investigators
- Engineering Research Centers
- Calculus Reform
- Instructional Labs
- Research Experience for Undergraduates

**1985**

**1990**
- Model Institutions for Excellence
- ADVANCE
- Louis Stokes Alliances for Minority Participation
- Alliances for Graduate Education and the Professoriate
- Advanced Technological Education

**1995**

**2000**
- NAE Engineer of 2020
- NAE Center for Advancement of Scholarship in Engineering Education
- Science, Technology, Engineering & Mathematics Talent Expansion Program
- Department Level Reform
- Research Experience for Teachers
- Centers for Teaching and Learning

**2005**
- American Competitiveness Initiative
- NAE/NAS Gathering Storm
- NAE Educating the Engineer of 2020
- Engineering Education Departments
- Research Agenda for Engineering Education
Coalitions

Purpose:

◦ To address industry’s call for graduates who are better prepared for current engineering practice, and to attract more women and minorities to engineering careers.

◦ Started in 1990, reform by teams of schools for 10 years at $2 to 3 million dollars per year.

◦ Together, these schools (4 yr and 2 yr) enrolled over thirty percent of the students who were studying engineering in the U.S. at that time.

Investment: $160 million total by the Directorate for Engineering

Assessment: SRI assessed the Coalition program after the first 5 years, finding:

♦ Helped to meet ABET 2000 criteria,

♦ Accomplished some unique successes in some universities,

♦ Developed some course/text materials,

♦ “Cannot be said to be the comprehensive and systemic new models for engineering reform anticipated,

♦ “Limited evidence of actual adoption outside the participating institutions.” Issues of scalability and transferability remain.
Purpose:

◆ **Support dialogue** about new ABET criteria (EC2000), and the training of evaluators to implement it. Are engineering graduates better prepared under the new ABET criteria?

◆ **Investment**: $1 million by the Directorate for Engineering

◆ **Assessment**: Penn State Center for the Study of Higher Education, in 2005, found:
  
  ◆ Greater emphasis on and gains in student professional skills
  ◆ More active learning
  ◆ High levels of faculty support for continuous improvement
  ◆ 2004 graduates are better prepared than their 1994 counterparts
  ◆ However, found mixed results on the degree to which scholarship of teaching was valued in the faculty reward structure
Purpose:

◆ Initiated in 1985, the Engineering Research Centers (ERCs) generate innovations in research and education impacting curricula at all levels from pre-college to life-long learning.

◆ One ERC focuses its research on developing new teaching/learning educational technologies for bioengineering education (VaNTH).

Investment: $12 million/year for education portion of ERCs by the Directorate for Engineering, including $3 million for VaNTH.

Assessment: SRI assessed the ERC program in 2002.

Key Findings:

◆ Education/Curriculum: Over the twenty year period, ERCs produced 144 new degree programs, 722 new multidisciplinary courses, 1261 modified courses and 187 texts. Employers reported that for 7 performance characteristics, supervisors find ERC graduates significantly better prepared for the practice of engineering than non-ERC trained engineers.

◆ Perceptions of Engineering: ERCs engaged 523 teachers in RET programs and 6,678 students in engineering activities in 2005.
Emerging Trends (Supply / Demand)

(1) U.S. Population (20-24 year olds, NSB-2008)

<table>
<thead>
<tr>
<th>Year</th>
<th>White</th>
<th>African-American</th>
<th>Hispanic</th>
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<tbody>
<tr>
<td>2000</td>
<td>11.8 mil</td>
<td>2.8</td>
<td>3.4</td>
</tr>
<tr>
<td>2050</td>
<td>11.8 mil</td>
<td>4.1</td>
<td>7.5</td>
</tr>
</tbody>
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18.0 mil 23.4 mil

(2) U.S. Global Business

- Caterpillar (50% of sales)
- Pfizer - $30 billion foreign earnings
- G.E. - $200 billion (50% foreign)
- IBM—2/3 of all revenue
- INTEL—75% of all revenues
- Google---80% growth rate overseas
Why Some Companies Make the Leap... and Others Don’t

GOOD TO GREAT

JIM COLLINS
Coauthor of the bestselling BUILT TO LAST
### Face the Brutal Facts

<table>
<thead>
<tr>
<th></th>
<th>1985</th>
<th>1995</th>
<th>2005</th>
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<tbody>
<tr>
<td>BS Eng (Degrees)</td>
<td>70,000</td>
<td>64,000</td>
<td>66,000</td>
</tr>
<tr>
<td>US Enrollment</td>
<td>12.3 million</td>
<td>15.6 million</td>
<td>17.3 million</td>
</tr>
<tr>
<td>Eng Intention</td>
<td>11%</td>
<td>8.1%</td>
<td>8%</td>
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<tr>
<td>(freshmen)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>9.6</td>
<td>8.6</td>
<td>7.2</td>
</tr>
<tr>
<td>Hispanic</td>
<td>12.6</td>
<td>11.2</td>
<td>6.4</td>
</tr>
<tr>
<td>Asian</td>
<td>23.9</td>
<td>13.3</td>
<td>15.0</td>
</tr>
<tr>
<td>Eng PhD</td>
<td>3200</td>
<td>6000</td>
<td>6400</td>
</tr>
<tr>
<td>U.S. Citizen</td>
<td>(40%)</td>
<td>(40%)</td>
<td>(31%)</td>
</tr>
<tr>
<td>Female Citizens</td>
<td>119</td>
<td>374</td>
<td>397</td>
</tr>
</tbody>
</table>
### EEC Objectives for 2020

<table>
<thead>
<tr>
<th>Objective</th>
<th>Description</th>
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<tr>
<td>1.</td>
<td>Enhance the K-12 Pathway and its Diversity; * 10% of all matriculates study engineering.</td>
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<td>2.</td>
<td>Promote the Success of the Undergraduate Learning Experience; * 3 of 4 students complete BS in engineering.</td>
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<td>3.</td>
<td>Improve the Pathway to Graduate Engineering Programs for US and Permanent Residents; * 5000 PhDs granted to domestic students.</td>
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<td>4.</td>
<td>Build a Culture of Discovery and Innovation in Engineering through Multi-Disciplinary Centers; * 1000 Center-related students graduate annually.</td>
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Innovations in Engineering Education ($9 Mil)

- Proposals due April 30, 2008
  Expansion (500k) and Exploratory (100-150k)

(1) How People Learn (Expansion)
(2) K-12 Partnerships (Exploratory)
(3) Business of Engineering (Exploratory)
A couple has a combined student loan debt of over $500,000, but feel its worth the investment in their Engineering Ph.D. degrees

*Money Magazine, November 16, 2007*
Law, Medicine
- Students willing to incur substantial debt

Engineering
- Virtually all graduate education is subsidized
- The Ph.D. is a byproduct of the research business
- How many students would sign up for an Engineering Ph.D. if there were no RA?
Engineering Education

- K-12 Initiatives
  - Project Lead the Way
  - AP in Engineering
- Undergraduate Education
  - REU Programs
  - DLR efforts
- Graduate Education?
Concept

Results

Current Engineering Ph.D.

Transformative Results

Renaissance Engineering Ph.D.

PI’s Great Research Idea

PI’s Same Great Research Idea
7300 U.S. Engineering PhDs in (2005)
31% to US. Citizens, Permanent Residents
30% of PhDs move into Academia
• US PhDs
  • Ready for Classroom?
  • Ready for Industry?
Europe provides more Eng PhDs (2003)
• Asia provides more Eng PhDs (2003)
Salary increases for PhDs:
60% less than MS
43% less than BS

So MS students make more money, more quickly.