Committee on K-12 Engineering Education
National Academy of Engineering

Directorate for Engineering
Advisory Committee
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Engineering...

About increasing our nation's capacity to perform.

Record $763 Billion Annual U.S. Trade Gap
(5th consecutive year to hit a new high — up 6.5%)

Asia = China, Japan, and South Korea.

Physical/biological sciences = physical, biological, earth, atmospheric, and ocean sciences.

Source: Science & Engineering Indicators, 2006
Where the Engineers Are...

- Impact of globalization on the engineering profession — a deeper look at China and India (Wadhwa and colleagues, Duke University)

- To guide education policy and maintain our innovation leadership, we must
  - Assess comparative engineering education — US and major new competitors (China and India)
  - Explore factors driving US trend toward outsourcing
  - Identify sources of current US global advantages
  - Ascertain what US can do to keep its economic edge
- No indication of shortage of engineers in US
China’s Undergraduate Engr Educ

- No standard definition of engineer; data includes ~half 2-3 year degrees
- Policy changes 1999 – transform engineering education from “elite” to “mass education”
  - Increasing enrollment
  - Decreasing salaries
  - Decreasing faculty (dramatic increase in class size)
  - Decreasing # of technical schools
- Only ~15 of tech schools produce high quality grads, so supply of graduates from top tier universities is limited
- Slowing enrollment growth in high ed to combat unemployment — engineering enrollments likely to level
India's Undergraduate Engr

- Public education inseparable from caste system
- 974 private engineering colleges in 2004
- Private sector “finishing school” for engineers
- Quality ok across board for top graduates
- Corporate folks conclude most graduates can become productive in a reasonable period
- 75% — adequate supply of well qualified entry level engineers
Engineering Offshore - Questions

- Surveyed 58 companies that outsource engineering jobs
- Were companies going offshore because of US worker deficiencies?
- Relative strengths or weaknesses of engineering graduates?
- What skills would give US graduates greater advantage?
Engineering Offshore Findings

- Majority did not mandate job candidates hold a four-year engineering degree
- US engineering jobs more technical than those sent abroad (44%)
- 37% US engineers more productive
- 38% US engineers produced higher quality work
- No indication of shortage of US engineers
  - 49% of respondents say supply is adequate
  - High job acceptance rates
  - Fill 80% of openings in four months
So Why Go Offshore?

- Top destinations: India, China & Mexico
- Top reasons
  - Salary and personnel savings
  - Overhead costs savings
  - 24/7 continuous development cycles
  - Access to new markets
  - Proximity to new markets
- Future Plans — trend will continue or expand
- Responding to big opportunities in rapidly growing markets; increasingly cater to worldwide needs
Workforce Advantages

- **US engineers** — strong communication skills, business acumen, good preparation and skills, proximity to work centers, lack of cultural issues, sense of creativity and desire to challenge the status quo

- **Chinese engineers** — cost savings; a few said willingness to work long hours

- **Indian Engineers** — cost savings, technical knowledge, English language skills, quick learners, strong work ethic
Workforce Disadvantages

- **US engineers** — salary demands, supply, lack of industry experience

- **Chinese engineers** — inadequate communication skills, visa restrictions, proximity, inadequate experience, lack of loyalty, cultural differences, IP concerns, limited “big picture” mindset

- **Indian Engineers** — inadequate communication skills, lack of specific domain knowledge or experience, visa restrictions, proximity, limited project mgmt skills, high turnover rates, cultural differences
More US Competitive Findings

- Want advanced engineering degrees for higher level R & D jobs
- ~60% of US engineering PhDs earned by foreign nationals — more and more returning home
- China racing ahead in PhD production; India seriously lagging
- Shortage of PhDs for US faculty positions
Immigrants increasingly fueling growth of US engineering and technology businesses

First generation immigrants in engineering and tech company’s founded ’95-’05 (contacted 2054 companies)
- 25% at least one key founder foreign born (employed 450,000 workers and generated $52B in sales)
- 26% of immigrant-founded companies Indians

24% of US patents filed in ‘06 had foreign national inventors (Chinese and Indians largest groups)

Indians lead in business creation; Chinese in IP creation
Why Such an Immigrant Impact?

- May be that education level differentiates them...
- Most immigrant business founders hold advanced degrees in math and science-related fields.
- Most studied and stayed after graduation.
- So what?
  - Improving K-12 education is critical.
  - More education in math and science leads to greater innovation and economic growth.
  - Can’t continue to depend on China and India to supply talent for engineers who seek advanced degrees.
# BS Engineering Degrees

### 2005 Engineering Degrees by Ethnicity & Gender

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>19.6%</td>
</tr>
<tr>
<td>African American</td>
<td>4.9%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>6.5%</td>
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</tbody>
</table>

All lower than 2000!

African Americans, Latinos and Native Americans comprise 30% of college-age people, and 25% of the U.S. workforce.

Source: Engineering & Technology Degrees, 2005 — Engineering Workforce Commission
K-12 to Increase Diversity...

- Beyond fairness
- Creative profession
- Creativity stems from those that *do* engineering
- Economic imperative
- Tap into our talent reservoir
- Population that is more representative of society
- To do less is poor engineering!

“The Statue of Liberty’s torch must light the way for all within our borders”

— Shirley Jackson, President, RPI
High School Juniors

11th Grade PSAT Takers (’04) 1.44M

Interest in Engineering Major 8.3% *
- Girls 2%
- Boys 16%

Interest in Engineering Career 5.7%
- Girls 1%
- Boys 11%

* Would produce 119,520 new engineers for the U.S. workforce

Source: The College Board
Extraordinary Women Engineers

- 2005 needs assessment of >5,000 high school girls, teachers, counselors
- Gender divide is alive and well with Gen Y girls
  - Engineering perceived as a man’s profession (not for them)
  - Little encouragement for girls to consider engineering
  - Do not understand what engineering is
Messages Misaligned with Women’s Motivators...

Career motivators hinge upon relevance

- Job must be rewarding
- Must be enjoyable, make a difference and be flexible
- Profession must be for someone “like me”
- Don’t want to be engineers — want to give back to society!

Messages not relevant...period!

Engineering messages they hear

- Have to love math and science
- Challenging, but if you work hard you can do it
- Don’t include benefits and rewards of being an engineer
Fed-Ex failed to deliver 30% of their packages on time?

Samsung’s televisions met industry standards only 25% of the time?

McDonalds provided good customer service only to certain types of customers?

Consumers were forced to accept 30-year old products?

Would we accept this mediocrity?
Consider U.S. High Schools

- Don’t graduate 30% of students
- Allow 25% of students to read below grade level
- Prepare only 7% of poor students for college
- Were conceived to prepare students for an industrial economy
...And U.S. Engineering Colleges

- Graduate <60% of entering students
- Teach the way were taught
- 35% think engineering “not worth the hard work”
- Capitalize little on advances in science of learning
- Don’t implement strategies known to retain under-represented students
- Not preparing engineers for global careers
- Do little to promote public technological literacy

“Engineering is changing rapidly and engineering education has to change even faster for us to maintain our quality of life.”

— William Wulf, President, National Academy of Engineering, 2003
### Public Perceptions of Engineering

<table>
<thead>
<tr>
<th>Feature</th>
<th>Engineers</th>
<th>Scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make strong leaders</td>
<td>56%</td>
<td>32%</td>
</tr>
<tr>
<td>Care about the community</td>
<td>37%</td>
<td>51%</td>
</tr>
<tr>
<td>Sensitive to societal concerns</td>
<td>28%</td>
<td>61%</td>
</tr>
<tr>
<td>Save lives</td>
<td>14%</td>
<td>82%</td>
</tr>
</tbody>
</table>

“The public perceives engineers and scientists quite differently.”

—2003 Harris Poll

Source: Harris Poll, December 2003
Creating Tomorrow’s Engineers

Challenge: To develop globally aware, world citizens with highly honed critical thinking and creativity skills who can transfer their knowledge to other problem contexts.

“When you come to a fork in the road, take it”
—Yogi Berra
Engineering makes science and math *come alive* from the earliest encounter.

Engineering augments science and math learning via hands-on, inquiry-based approaches.

Capitalizing on engineering opportunities in life sciences.

Communicate the social context of engineering at a young age.
Career paths for engineers changing

Develop a creative and innovative person

Provide students an education, not a career

Conduct real research into better understanding why different educational methodologies work

Create a body of knowledge on how students learn

Beyond thinking critically to thinking deeply

Insanity “doing what you’ve always done and expecting different results.”

— Albert Einstein (or Benjamin Franklin)
Attain cultural literacy

Embrace global competency

Understand contemporary issues

Develop world citizens
  - Stewards of world resources
  - Consider long term impacts of their work
  - Prepared to consider societal issues and global, economic and environmental impacts

Generate interest >35% “worth the extra work”

“...production and employment of scientists and engineers are not well understood as a system.”

— National Science Board, 2003
K-12 Engineering — the Reality

- 2002 NAE Survey
- 177 survey respondents w/ outreach programs
- $403M annual engineering outreach expenditures!
- No objective data on effectiveness
- Little evidence of impact
- Some message consistency
  - Engineering is a fun, creative, exciting, important career
  - Math and science are fun
  - Engineers are important & contribute to the quality of life
- NAE embarked on *Public Understanding of Engineering* research project in 2006

Source: NAE Raising Public Awareness of Engineering survey, 2002
NAE 2007 Public Understanding

- Stop talking about engineering in terms of benefits and required skills.
- Start talking in terms of ideas and impact.
- Not a world of challenging math and science...but a world of difference.
Position engineering experience as discovery, design, imagination, innovation and contribution.
Committee on K-12 Engineering Education

- Just held 1st work session
- Chaired by Linda Katehi; led by Greg Pearson
- **Goal** — provide guidance to key stakeholders re: creation and implementation of K-12 engineering curricula and instructional practices — focusing on the connections among science, technology, engineering and mathematics education

A collaboration between NAE and NRC’s Center for Education
Committee on K-12 Engineering Education

- Key stakeholders
  - K-12 science, math & technology education communities
  - Engineering and science practitioners engaged in K-12
  - Education policy makers at all levels
  - Industries concerned w/ quality and composition of US science, engineering and technical workforce
- Public review of draft report
- NAE/NRC K-12 Engineering Education report

“We can’t have a democracy without an informed citizenry.”

— Bill Wulf (quoting Thomas Jefferson)
NAE/NRC K-12 Engineering Process

- Survey the landscape of K-12 engineering initiatives
- Review evidence of impact from these initiatives
- Describe ways K-12 engineering content has
  - Incorporated science, technology and math concepts
  - Used science, technology and math concepts to explore engineering concepts
  - Used engineering as a context to explore science, technology and math concepts
- Report on intended learning outcomes of K-12 engineering education initiatives
- Dissemination conference
Key Issues and Guiding Questions

**Issue #1:** Multiple perspectives exist about the purpose and place of engineering in K-12 classrooms, leading to emphases on very different outcomes.

**Guiding Question:** What are realistic and appropriate learning outcomes for engineering education in K-12?
**Key Issues and Guiding Questions**

**Issue #2:** Not been a careful analysis of engineering education within a K-12 environment that looks at possible subject intersections.

**Guiding Question:** How might engineering education complement the learning objectives of other content areas — science, technology and math — and how might these content areas complement engineering education learning objectives?
Key Issues and Guiding Questions

**Issue #3:** There has been little, if any, serious consideration of the systemic changes in the US education system that might be required to enhance K-12 engineering education.

**Guiding Question:** What educational policies, programs and practices at the local, state and federal levels might permit meaningful inclusion of engineering at the K-12 level in the US?
What Does Success Look Like?

An increase in understanding about the role and contribution of design and experimentation in K-12 engineering among the stakeholder group

- Stakeholder participation in two project workshops
- Stakeholder participation in end-of-project dissemination conference
- Post-conference follow-up by stakeholders
  - Requests for copies of report
  - Stakeholder-organized workshops focused on the study topic
  - Requests for briefings on the report
NAE/NRC K-12 Project Timeline

- Project complete ~18 months from now
- Workshops (2) ~6 and 8 months from now
- Public comment period ~ 9 months from now
- Conference and report release late summer 2008
Other Stuff

- NSF GK-12 initiatives — ~26 in engineering (GRE)
- NSF Research Experiences for Teachers Pgm (RET)
- NSF NSDL TeachEngineering digital library (DUE)
- NAE — explore developing standards for K-12 engineering (NSF proposal)?
- College Board evaluating a “Pre-AP” engineering course of study (led by Leigh Abts U Md)
Looking Forward for K-12 Engineering Education

Beyond the K-12 Holy Grail to making a difference for US economic and intellectual competitiveness...

Jackie Sullivan
University of Colorado at Boulder
Duke Report:

http://www.issues.org/23.3/wadhwa.html#