Committee on K-12 Engineering Education
National Academy of Engineering

Directorate for Engineering
Advisory Committee
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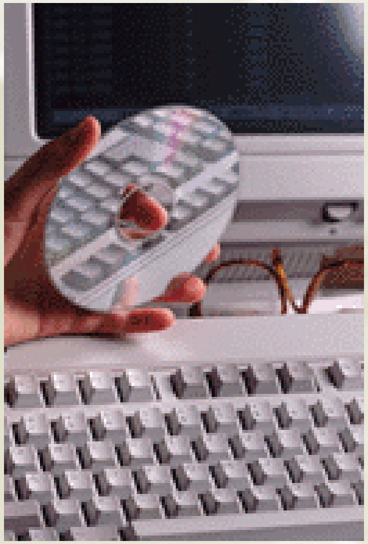
Engineering...

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%)

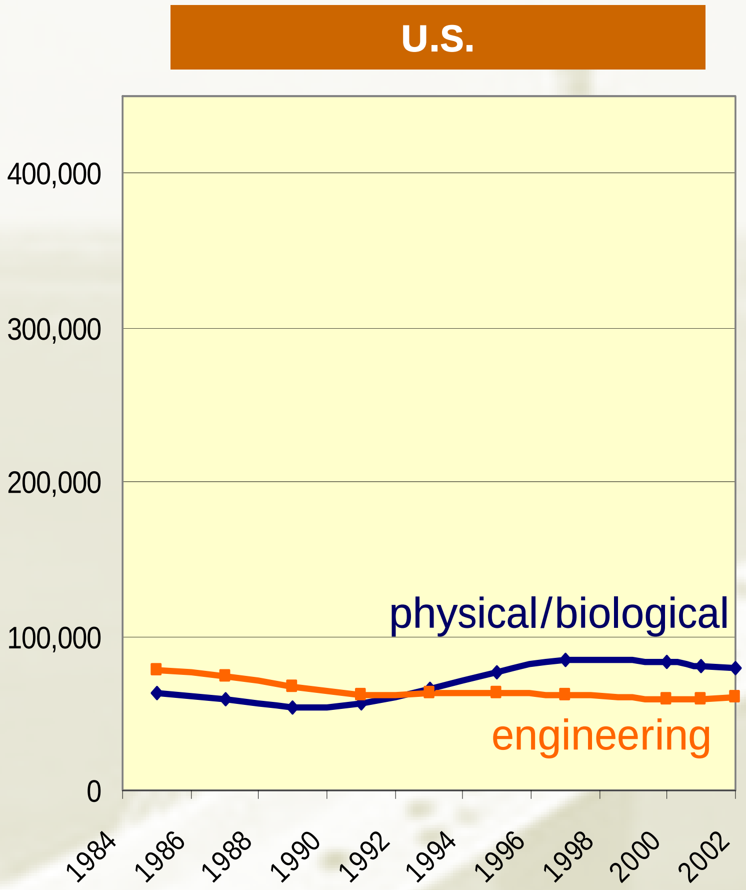


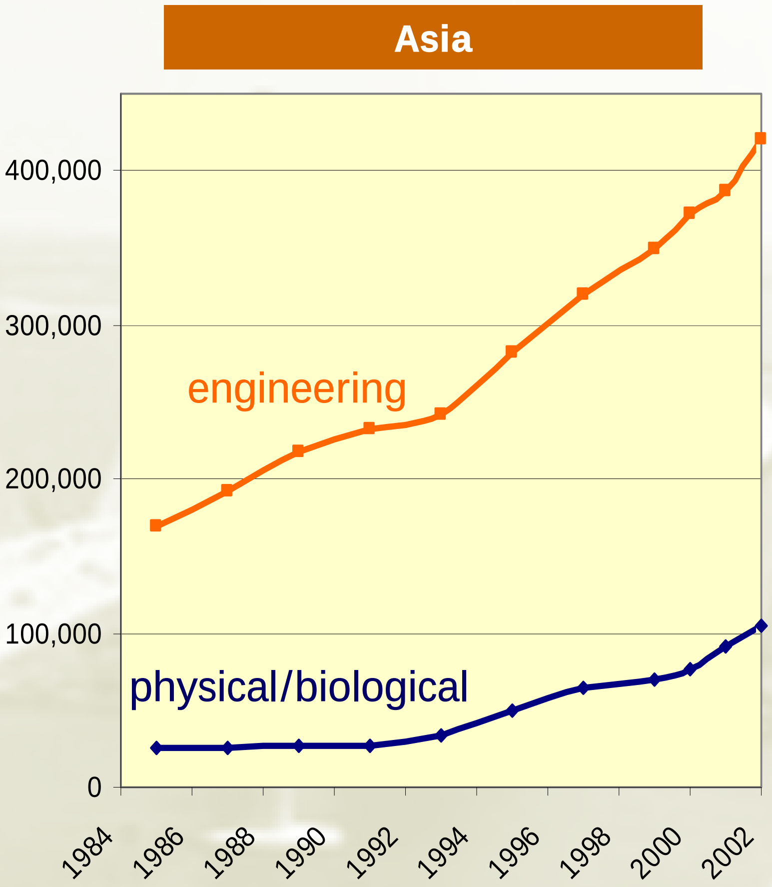




Source: New York Times, February 14, 2007

S&E Degrees (quantity)





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

More US Competitive Findings

- Immigrants increasingly fueling growth of US engineering and technology businesses
- First generation immigrants in engineering and tech co'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

Women	19.6%
African American	4.9%
Hispanic	6.5%

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% *

Fall 2004

Girls 2%

Boys 16%

Interest in **Engineering Career** 5.7%

Fall 2002

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

K-12 Engineering Motivations
What if…

- 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

	Engineers	Scientists
Make strong leaders	56%	32%
Care about the community	**37%**	51%
Sensitive to societal concerns	**28%**	61%
Save lives	**14%**	**82%**

"The public perceives engineers and scientists quite differently."

—2003 Harris Poll

Source: Harris Poll, December 2003

Creating Tomorrow's Engineers

“When you come to a fork in the road, take it”
—Yogi Berra

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

K-12 Engineering — the Beliefs

- Engineering makes science and math *come alive* from the earliest encounter
- Engineering augments science and math learning via hands-on, inquiry-based approaches
- Capitalize on engineering opportunities in life sciences
- Communicate the social context of engineering at a young age

K-16 Engineering — the Beliefs

- 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)

K-16 Engineering — the Beliefs

- 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 *Pubic Understanding of Engineering* research project in 2006

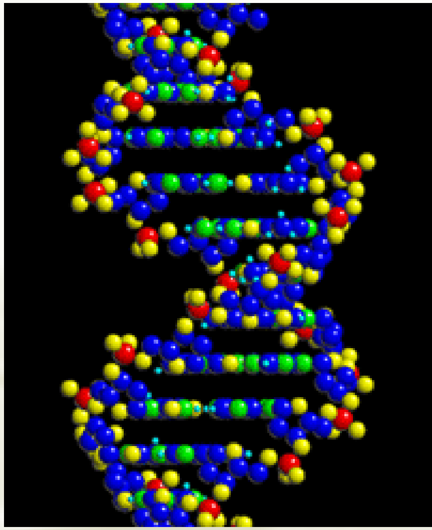
Source: NAE Raising Public Awareness of Engineering survey, 2002

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*

NAE 2007 Public Understanding

- 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

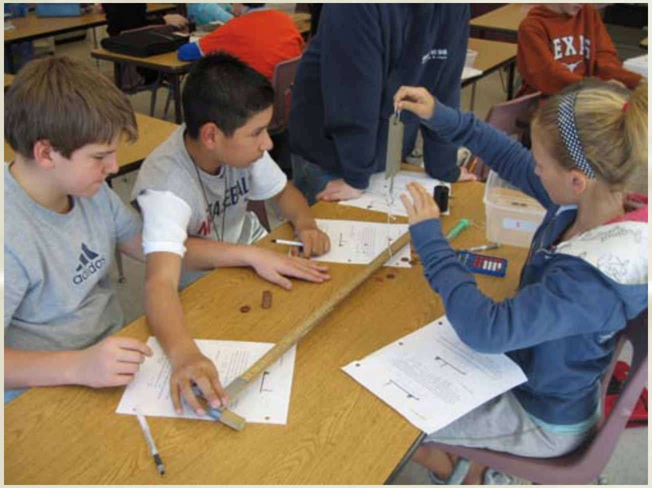
Issue #1: Multiple perspectives exist about the purpose and place of engineering in K-12 classrooms, leading to emphases on very different outcomes.

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#