Broadening Participation in Engineering: A K-16 Approach

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Engineering Advisory Council
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Prepared 2020 Engineers

- Dramatic expansion of knowledge
- Integration of technologists into public policy
- Globally, >50% of population <18 years old
- 8B people in world (+1.5B in Asia and Africa)
- U.S. population ~50% nonwhite by 2050
- Engineering solutions to serve a more diverse community

Global STEM Degree Trends

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Global STEM Degree Trends

- Taiwan
- South Korea
- France
- Spain
- Japan
- United States
- Mexico
- China

Percent of 24-Year-Old Population

BS Degrees Awarded

- All Bachelor's Degrees
- Engineering B.S. Degrees
- Women
- Underrepresented

S&F Degrees

- First university S&F degree
- Engineering
- Natural science

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**S&E Degrees**

**U.S.**

- Physical/biological sciences
- Engineering

**Asia**

- Physical/biological sciences
- Engineering

Source: Science & Engineering Indicators, 2006

**Are We Achieving Success?**

- A call to arms
- Role of engineers as decision makers
- Technology users *and* developers
- Global implications?

**BS Engineering Degrees**

2005 Engineering Degrees by Ethnicity & Gender

- Women: 19.6%
- African American: 4.9%
- Hispanic: 6.5%

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

**Diversity: Beyond Fairness**

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

"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.

**High School STEM AP**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP Computer Science</td>
<td>15%</td>
</tr>
<tr>
<td>AP Biology</td>
<td>59%</td>
</tr>
<tr>
<td>AP Chemistry</td>
<td>47%</td>
</tr>
<tr>
<td>AP Calculus</td>
<td>46%</td>
</tr>
<tr>
<td>AP Physics</td>
<td>31%</td>
</tr>
</tbody>
</table>

Source: The College Board, 2006
Women: Good for the Bottom Line

- The Bottom Line (A study conducted by Catalyst).
- Examined Fortune 500 companies 1996-2000
- Corporate performance and gender diversity linked

**Conclusion:** Top performing companies have a higher representation of women on their top leadership teams.

"It makes the best business sense to have a diverse workforce..."
— Tony Comper, Chair and CEO, BMO Financial Group

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
- Little encouragement for girls to consider engineering
- Do not understand what engineering is

**Career influences (rank order):**
- Parents
- Peers/friends
- Teachers and counselors
- Media (Dilbert)

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

Public Perceptions of Engineering

<table>
<thead>
<tr>
<th></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

What Do Engineers Do?

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Builds/constructs/makes things</td>
<td>38%</td>
<td>26%</td>
</tr>
<tr>
<td>Designs/draws/plans</td>
<td>19%</td>
<td>27%</td>
</tr>
<tr>
<td>Mechanic/mechanical work</td>
<td>9%</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Train operator</strong></td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Creates/ is creative</strong></td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Mathematics/physics</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Develops new technologies</td>
<td>3%</td>
<td>-</td>
</tr>
<tr>
<td>Application of technology</td>
<td>2%</td>
<td>-</td>
</tr>
<tr>
<td>Equipment maintenance repair</td>
<td>2%</td>
<td>-</td>
</tr>
<tr>
<td>Works with computers</td>
<td>2%</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Harris Poll, December 2003

Technological Literacy

- Being a technologically literate person
- Component of basic literacy
- Understand technology to make responsible decisions
- Explain how everyday things work
- Smart consumers
- Social and economic impacts far reaching

"We have a society profoundly dependent upon and ignorant of technology."
— William Wulf, President, National Academy of Engineering, 2003
The Global War for Talent

- Global shift of jobs
- Decline in U.S. workers
- China and India adding workers
- Pressure not on job availability
- Pressure ➔ skills to do the job at the right price
- Global and relevant education will be our safety net for global workforce rebalancing

Global Economies

U.S. economy: nimble and sustainable
- Productive citizenry
- Innovation at our core
- Excellent banking system
- Rejuvenation of immigration
- Companies that are global giants

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.

We’re Fossilized...

- Schools of Education fail our nation’s youth
  - Least prepared students on campus
  - Change comes too slowly
  - Corner on the market for teacher preparation — despite overwhelming evidence to the contrary
- Colleges of Engineering — any better?
  - Evolve too slowly — systemic changes haven’t stuck
  - Little sense of urgency
  - Few faculty have practiced engineering outside academia
- Engineering profession disconnected from educational system

What if...

- Fed-Ex failed to deliver 30% of their packages on time?
- Samsung’s televisions met industry standards only 25% of the time?
- McDonald’s provided good customer service only to certain types of customers?
- Consumers were forced to accept 30-year old products?

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
Consider U.S. Engineering Colleges
- Graduate <60% of (top) entering students
- Changed little in last 30+ years
- We teach the way we were taught
- Capitalize little on advances in science of learning
- Don’t pervasively implement strategies known to retain under-represented students
- Not preparing engineers for global careers
- Don’t 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

Consider Our Profession
- Lost connection of engineering to society
- Hidden in walls of corporations — little visibility
- Solving problems vs. creating the solutions to the world’s grand challenges
- Abdicate our responsibility as policy makers
- Content to be a gaggle of geeks?

“...The stakes are too high for government to be a spectator sport.”
— Congresswoman Barbara Jordan

Creating Tomorrow’s Engineers
Whom and what can we learn from?

Small Schools Initiative
Small high schools (<400 students)
- Reduce harmful power of poverty by 30-50%
- Most promising achievement gains by low-income and ethnic minority students
- Personalized learning environment
- Relationships reduce alienation
- Dropout rates decrease
- Research → Quality and intensity of high school coursework

Source: Pursuing Excellence, National Center for Education Statistics, 1998

Teach for America – a Model for Engineering?
- Leverages the altruism of bright college graduates
- Highly selective
- Teach in nation’s most troubled schools
- Impacts the lives of 280,000 youth
- Challenges the status quo “regulatory approach” to teacher preparation and quality
- It works!
Creating a new generation of leaders aware of the challenges in public education...

TeachEngineering Digital Library
- Hands-on engineering curricula created for grades 3-12
- Web-enabled
- Standards-based
- Searchable

Search example: Find engineering lessons about the laws of motion that address national science standard 2 for 5th grade...
**K-12 Engineering Corps**
- Connect K-12 and university system
- Engineering students teach in K-12 schools as part of their engineering curriculum
- Touch the lives of youth (learn by teaching)
- Boundary crossing experiences
- Cements commitment to the profession
- A low-cost sustainable approach
- Use TeachEngineering as resource

“Working at the frontier, we must ride the crest of the wave and arrive at new shores.” — Joe Bordogna, 2003

**A Systems Approach: K-12 Education**
- Provide a more rigorous education to larger numbers of students (urban)
- Learn and apply lessons from
  - Charter school movement
  - Small school movement
  - HeyMath math teaching platform
  - Schools with amazing achievement results (Norfolk)

“Our students are our students — the demographic stays the same — so the only thing you can do is change what you do.” — Lauren Campsen, Principal, Norfolk School District, 2005

**A Systems Approach: K-12 Education**
- Mandated engineering coursework in high school (6 states)
- Expand K-12 offerings to capitalize on engineering opportunities in life sciences
- Partner to communicate the social context of engineering
- Texas — plans to create 35 “high tech highs”

**A Systems Approach: Engineering Education**
- Career paths for young engineers changing
- How to 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
- Understand the root causes of engineering challenges and solutions
- Insanity “doing what you’ve always done and expecting different results.” — Albert Einstein (or Benjamin Franklin)

**A Systems Approach: Engineering Education**
- Attain cultural competency
- Embrace global competency
- Understanding 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

**A Systems Approach: Our Profession**
- The connection of engineering to society
- Prominently visible in public life
- Broadly appealing national message — joys, rewards, making a difference
- Forcing function for education reform
  - Higher ed reform — hiring bonuses for the skills & knowledge you want?
  - Establish K-12 engineering coursework/frameworks in the other 44 states
- Beyond the third gender — men, women, and me

“Real girls wear concrete and pearls” — Smersh Design Jewelry, Seattle, WA
Lafayette TEAMS
Technology and Engineering to Advance Math and Science
A ten-year, grades 3-12 engineering initiative...to make the possible probable

TEAMS Vision
- Create engineering opportunities in local low-performing K-12 schools
- Help youngsters create a bright future for themselves
- The long view — engaging youth for 10 years (grades 3-12)
- Long-term CU partnership
- Generate more interest in engineering by diverse students
- CU-Boulder becomes school of choice for engineering-bound students

Why Lafayette Schools?
- Ideal Student Population
  - 34% low income youth
  - 38% minority (high Latino)
  - 22% ESL Learners
  - Many 1st generation college-bound
- District committed to revitalizing these schools
  - High school PreEngineering Academy
  - High School IB program (new fall ’06)
  - Elementary Pre-IB program (new)
  - Elementary science & math focus school (new)

’05-’06 in Action
1,865 students — engineering weekly in 70 classes
- 27 grades 3-5 elementary classes
- 29 middle school classes
- 19 science
- 6 mathematics
- 4 technology
- 9 high school classes
  - 6 Pre-Engineering Academy
  - 3 science
- TEAMS clubs in five schools
- TeachEngineering digital library

Resources
- Passion for service of CU students, faculty & staff
- NSF ten year K-12 engineering grant (began in ’98)
- Dept. of Education four-year grant
- Gates Family Foundation support
- Committed principals and district
- Excited teachers - all six schools
- TeachEngineering curriculum
- CU Guaranteed admissions agreement

Needs
- CU commitment after NSF grant
- Industry partnerships to refine long-term model
- Endowment — scholarships, student stipends
- K-12 service learning throughout college
- Effective recruiting strategy
- Engage families long term to create community
Denver School of Science & Tech

- New public charter prep school founded in 2004
- 425 highly prepared urban youth
- First graduates in 2008
- Ideal student demographics:
  - ~50% low income youth
  - ~50% first generation
  - 66% students of color
  - ~45% girls
- New high-tech school facility modeled after ITL Laboratory

Denver School of Science & Tech

- School culture for achievement
- CU Creative Engineering courses every term
- Summer deep dive enrichment camps
- Tremendous diversity opportunity
- On our doorstep
- Graduates will be highly sought by colleges nationwide
- So far, our College is provider of choice...how can we cement this?

Our College Opportunities

- Become the national leaders in K-16 engineering education
- Expand K-12 service-learning opportunities
- Create abundance of diverse, well-prepared Colorado students excited about engineering
- Create an Engineering Education Dept.?
  - PhD in Engineering Education
  - BS/MS in Engineering Ed

Let’s Do It

- The challenge is great...
- ...so are the opportunities!

Last Thought...

“It is our choices, Harry Potter, that show what we truly are, far more than our abilities.”
--- Professor Dumbledore, Headmaster Hogwarts School for Witchcraft and Wizardry

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