Overview of Academies Report

Linda Katehi
University of California, Davis
Study Objectives

1. Survey the K-12 engineering education “landscape”

2. Review data on impacts

3. Analyze the connections between engineering and the other STEM subjects

4. Report on the intended learning outcomes (e.g., vocational vs. pre-professional vs. general college) of the various initiatives
Findings: Scale of Effort

• K-12 engineering education is a small but growing presence in schools

• About 6 million K-12 students have experienced a formal K-12 engineering curriculum since the early 1990s

• About 18,000 K-12 teachers have received professional development, almost all of it in-service
Findings: Impact

The most intriguing possible benefit of K-12 engineering education relates to improved student learning, achievement, and interest in mathematics and science

- Positive effects have been demonstrated, but not universally
- Learning gains may be greater for minorities and low-SES students
- More research is needed to tease out specific causal relationships
Findings: Professional Development

As reflected in the near absence of pre-service education and the small number of teachers who have experienced in-service PD, teacher preparation for K-12 engineering education is far less developed than for other STEM subjects.
Findings: Diversity

Lack of diversity appears to be a serious issue for K-12 engineering education

- Uneven portrayal of women and minorities
- Bias in certain learning activities and examples
- Few student demographic data being collected
- Example: Largest program, PLTW, has only 17% female students
Findings: STEM Education

• Current STEM education and education policy do not reflect the natural, real-world interconnectedness of the four STEM components.

• There is considerable potential value in increasing the presence of engineering in STEM education that addresses the current lack of integration in STEM teaching and learning.
Selected Recommendations

• Develop more impact data for existing and new K-12 engineering programs

• Conduct research on how engineering design can be better connected to science inquiry and mathematical reasoning in curriculum and professional development

• Begin a national dialog, spearheaded by ASEE, on the preparation and certification of teachers of K-12 engineering

• Define and explore the implications of “STEM literacy”
Planned ASEE Workshop on Preparing Teachers of K-12 Engineering

Elizabeth Parry
North Carolina State University
Recommendation 4 from Academies Report

The American Society for Engineering Education (ASEE), through its Division of K–12 and Pre-College Education, should begin a national dialogue on preparing K–12 engineering teachers to address the very different needs and circumstances of elementary and secondary teachers and the pros and cons of establishing a formal credentialing process. Participants in the dialogue should include leaders in K–12 teacher education in mathematics, science, and technology; schools of education and engineering; state departments of education; teacher licensing and certification groups; and STEM program accreditors. ASEE should consult with the National Center for Engineering and Technology Education, which has conducted research on this topic.
A Role for Engineering Schools in K-12 Curriculum Development

Linda Abriola
Tufts University
Why should we care about K-12?

A chance to fill the engineering pipeline with qualified students.
Why should we care about K-12?

Approximately 6,000 high school seniors are in jeopardy of not graduating next spring because they have not yet passed the new science MCAS exam, state education officials announced yesterday, possibly setting the stage for a new revolt against the 11-year-old standardized test system.

A chance to change the face of engineering and improve technological literacy
Aspiring teachers fall short on math
Nearly 75 percent fail revamped section of state licensing test

By James Vaznis
Boston Globe Staff / May 19, 2009

MALDEN - Nearly three-quarters of the aspiring elementary school teachers who took the state's licensing exam this year failed the new math section, according to results being released today that focus on the subject for the first time.

Education leaders said the high failure rate reflects what they feared, that too many elementary classroom and special education teachers do not have a strong background in math and are in many ways responsible for poor student achievement in the subject, even in middle and high schools.....

......

A chance to improve the education of the educators
What is needed

- Tools and curricula for K-12 engineering education and project-based learning
- Partnerships with schools of education to develop teaching curricula for future teachers
- Workshops and continuing education opportunities for existing teachers
- Evolution of engineering education as an education discipline (???) (as an engineering discipline???)
- Research on delivery, content, and impact
One example:
Tufts University Center for Engineering Education and Outreach (CEEO)

- A leader in supporting efforts to integrate engineering into K-12 education

- Three ‘pillars’ of center
  - Outreach (to classrooms and teachers)
  - Method and tool development
  - Education research
RoboLab Based on LabVIEW™, from National Instruments, uses an icon-based, diagram building environment to write programs that control the RCX.

SAM Animation is a software platform that allows the user to make stop-action movies using a USB or fire-wire real-time camera (i.e. web camera or webcam).
CEEO Paradigms for Teacher Education

- Educating the existing teacher
  - Student Teacher Outreach Mentorship Program (STOMP)
  - Summer LEGO Engineering workshops
- Educating the future teacher
  - Program for Engineers as Teachers (PET)
    - Undergraduate minor in engineering education within the School of Engineering
    - Develop a state-approved MAT for engineering certificate program within the Education Dept
- Educating the teacher of the teachers
  - Math, Science, Technology, Engineering (MSTE) Graduate Program (joint MS, PhD with Education)
Impact of CEEO activities

- 3200 participants in LEGO Engineering Conferences and Symposia since 2004, doubling from the end of 2007
- 5000 visitors to STOMPNetwork.org since its refresh launch in 2008
- 7000 K-12 Boston area students impacted by STOMP since 2001
- 200,000 visitors to SAMAnimation.com since its launch in 2007
- 500,000 copies of RoboLab sold since 2002
- 800,000 visitors to LEGOEngineering.com since its launch in 2006.

Anecdotal evidence for benefits **BUT** little research and few defensible data
Benefits of K-12 – University Partnerships

“If not us, then who?”

- **Direct**
  - Enhancing skills and knowledge of K-12 teachers
  - Inspiring students to enter the STEM pipeline
  - Engaging under-represented groups
  - Increasing technical literacy and problem solving abilities for all

- **Indirect**
  - Engaging and retaining students from underrepresented groups
  - Improvement of soft-skills for the university student
  - Development of industry-academic partnerships
  - Stimulation of education innovation and interdisciplinary research
How Messaging About Engineering Can Influence K-12 Outreach Efforts

Don Giddens
Georgia Institute of Technology
Objectives of the Project

- Identify a small number of messages that appear likely to encourage greater public understanding of engineering
- Test the effectiveness of these messages in a variety of audiences
- Disseminate the results of the message testing to the engineering community
Messaging Research Methodology

• Communications Audit – Review of previous research and communications materials
• In-Depth Interviews – educators, opinion leaders and engineers
• Focus Groups – youth ages 12-15 and 16-19, parents of kids ages 9-19 (Raleigh & Phoenix)
• Youth Triads – 3-person focus groups with kids ages 9-11
• Online Surveys – 1866 adults and 1768 youth ages 14-17 [margin of error ~4% @ 95% confidence]
Conclusions in a Nutshell

- Recast communications from personal benefits and skills needed to how engineers make a difference in the world.
- 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 one of discovery, design, imagination, innovation and contribution.
Most Appealing Messages – Survey Results

• Engineers are **creative problem-solvers**
• Engineering is **essential to our health, happiness and safety**
• Engineers help **shape the future**
• Engineers make a **world of difference**

❌ • Engineers **connect science to the real world***

*Least appealing overall, especially among teen girls
“Very” Appealing Taglines for Youth

- Ideas to Reality
- Dreams Need Doing
- Power to Do
- Bolder by Design
- Work Wonders
- Next Big Thing
- Life Takes Eng

Percent

- General Pop.
- Hispanic
- African American

Engineering is essential... to our health, happiness and safety
The Big Shift: Repositioning Engineering

• From
  • Personal Benefits and Needed Skills

• To
  • How Engineers Make A Difference In The World
The Role of Engineering Education Research in Improving K-12 Engineering

Leah H. Jamieson
Purdue University
Engineering Education Research: Key Questions

- **Why:** Research questions in K-12 engineering education *There’s a lot we don’t know*

- **Where:** The case for conducting engineering education research in Engineering *We should own our own future*
- Several Elementary Curricula: EiE, MEA
- Middle School Curricula: very little
- High School Curricula: PLTW (10% of high schools), EPICS High, Infinity
Things We Don’t Know

• What is / should be portrayed as engineering?
  *NAE EK12E: “Focus on design”*

• Possible futures: Impact of engineering education
  ... on learning in STEM subjects
  ... on K-12 student engagement and retention
  ... on understanding of engineering
  ... on career aspirations
  ... on technological literacy
  ... on life skills, including problem solving, critical thinking, design, collaboration, citizenship
Things We Don’t Know: Research on students/learners

- **Engineering thinking:** What are developmental stages in engineering thinking? What are engineering “habits of mind” in younger grades? What are age-appropriate learning progressions? How do stages of engineering thinking intersect with other developmental stages – intellectual, scientific, social?

- **Measurement:** How do we measure student learning in engineering?

- **Transfer:** Do engineering activities increase math/science learning?

- **Interest:** How do engineering activities translate to interest in engineering? How can we shape/alter student perceptions at different stages? How do we foster interest and competency in women and underrepresented minorities?

- **Effectiveness:** What works and why?
Things We Don’t Know: Research on teachers & school systems

- *Measurement:* How do we measure teachers’/administrators’ understanding of engineering? Attitudes towards engineering? Self efficacy?

- *Preparation:* How do we prepare teachers to teach engineering? K-12 teachers have well-documented difficulties math & science. What happens when you add engineering?

- *Positioning:* What “home” for standards works best for student learning? For preparing teachers?

- *Effectiveness:* What works and why?

**Overarching:** What will change if engineering concepts and practices are taught in K-12?
Is This Engineering Research?

Con:
- Topics and methodologies have more in common with education and science education research than with traditional engineering research
- Teacher preparation is well established elsewhere

Pro:
- K-12 engineering education needs a solid foundation
- It’s an opportunity to develop thematic integration that cuts across all of engineering, as a function of age
- Who else is qualified? Defining what K-12 engineering is requires understanding of engineering
- It’s a rich interdisciplinary area
- It’s an opportunity to shape our own future
Leveraging College Students and Secondary-School Partnerships in K-12 Engineering Education

Darryll J. Pines
University of Maryland
Outline

• The National Problem
• State Partnerships/Programs to increase pipeline
  • Associate of Science in Engineering-ASE Degree
• Scalable High School Partnerships
  • WWF: Early College Program-Engineering Math at Friendship High School, DC
  • SSWB: Tutoring/Mentoring Program
• Partnership between Government/Industry/Academia/Non-Profits
  • USA Science and Engineering Day on October 23-24, 2010
• Summary
The National Problem

“The US economy relies on the productivity, entrepreneurship, and creativity of its people. To maintain it’s scientific and engineering leadership amid increasing economic and educational globalization, the US must aggressively pursue the innovative capacity of all its people—women and men.”

2006-07 ASEE Data for US Engineering degrees:
• Total engineering BS degrees: 68,412 (down 1.2%)
  • Women: 18.1% (lowest since 1996)
  • Underrepresented Minorities: 12.8%
• Total engineering MS degrees: 22,730
  • Women: 22.4% (similar to previous years)
  • Underrepresented Minorities: 10.6%
• Total engineering PhD degrees: 3,486
  • Women: 20.8% (highest ever)
  • Underrepresented Minorities: 7.9%

“Need to put capital “E” back into STeM”

<table>
<thead>
<tr>
<th>Occupation</th>
<th>2006 Employment</th>
<th>Annual Openings</th>
<th>Annual Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer &amp; Information Scientists</td>
<td>1,820</td>
<td>73</td>
<td>1.3%</td>
</tr>
<tr>
<td>Programmers</td>
<td>6,150</td>
<td>199</td>
<td>0.3%</td>
</tr>
<tr>
<td>Software Engineers, Applications</td>
<td>11,495</td>
<td>234</td>
<td>4.9%</td>
</tr>
<tr>
<td>Software Engineers, Systems</td>
<td>12,875</td>
<td>637</td>
<td>3.5%</td>
</tr>
<tr>
<td>Support Specialists</td>
<td>11,670</td>
<td>555</td>
<td>1.6%</td>
</tr>
<tr>
<td>Systems Analysts</td>
<td>12,465</td>
<td>727</td>
<td>3.2%</td>
</tr>
<tr>
<td>Database Administrators</td>
<td>5,395</td>
<td>160</td>
<td>3.6%</td>
</tr>
<tr>
<td>Network &amp; Systems Administration</td>
<td>9,940</td>
<td>525</td>
<td>3.5%</td>
</tr>
<tr>
<td>Network Systems &amp; Data Communications Analysts</td>
<td>9,040</td>
<td>681</td>
<td>5.5%</td>
</tr>
<tr>
<td>Professors, All Other</td>
<td>12,400</td>
<td>473</td>
<td>0.3%</td>
</tr>
<tr>
<td>Total, Computer Specialists</td>
<td>54,440</td>
<td>2,200</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

Data Source: Maryland Department of Labor, Licensing and Regulation (Numbers are rounded).
State of Maryland-ASE Program
Associate of Science in Engineering

• What is the ASE-Associate of Science in Engineering?
  – The ASE is a Maryland statewide articulation agreement based on outcomes, not courses. Each ASE is built around a set of critical outcomes that all students must meet in the first two years of an engineering program.
    • Computer Engineering
    • Electrical Engineering

• Partners:
  – Maryland Higher Education Commission-MHEC
  – Maryland Association of Community Colleges
  – Public/Private Universities and Colleges in State
    • Capitol College
    • Loyola University
    • Morgan State University
    • Johns Hopkins University
    • Frostburg State University
    • University of Maryland, Baltimore County
    • University of Maryland, College Park
    • University of Maryland, Eastern Shore
ASE Degree: Pathway to Engineering

2-year institutions
ASE Degree
60 credits
Statewide Articulation Agreement Based on Outcomes

4-year institutions
Electrical Engineering
Computer Engineering

Maryland High Schools

Entry-level IT Jobs

University of Maryland
Partnership with The Woodrow Wilson Foundation: Early College Program

- **Friendship Collegiate Academy**
  - College Partners: University of the District of Columbia and University of Maryland
  - School Partner: Friendship Public Schools (charter)
  - Location: Washington, DC
  - Opened: added Early College program in Fall 2004
  - Principal: Peggy Pendergrass; Early College Dean: Arsallah Shairzay
  - Student Body: 1200 in Grades 9-12; 250 in Early College program

- The Early College program serves ninth to twelfth graders attending Friendship Collegiate Academy, a comprehensive high school located in northeast Washington, D.C. with a student body that is 99% African American. In addition to completing their required high school curriculum, students in the Early College program complete college-level coursework. Through teacher professional development and a federal AP grant, Friendship has extended rigorous college-level and college-readiness instruction across the school, with the goal of reaching all students in the high school. Friendship has also extended its college-readiness curriculum into its two middle schools.

- Engineering Math Readiness: Using the Wright State University Model for Engineering Math which includes engineering examples in calculus.
  - Get College credit and be properly prepared
  - Uses Adjunct Faculty and DoD Mentors
Partnership w/ Northwestern HS

1.5 miles away

THE A. JAMES CLARK SCHOOL of ENGINEERING
STEM Students w/o Borders
SSWB

• Launched in Spring 2010
• Pick a local high school: Northwestern High School
  – Enhance existing PLWT Program
• All UG Volunteers (Soph, Jrs, Srs) w/ UMD staff oversight
  – Objectives/Goals:
    • Enhance math, science, english skills
    • Expose students to Art of Engineering Design
• Tutors (AP Classes, English, Social Science)
  – 2 nights per week, some weekends
  – 20 UG students participating for 30 HS students
  – Each UG tutors for 3 to 5 wks
• Mentors (All engineering disciplines)
  – Shadow a student day
  – Invite Engineering Professionals to speak
• Tours of Engr. Facilities at UMD
  – Faculty and staff
USA Science & Engineering Festival

Festival Dates: 10/10/10 - 10/24/10
Expo on the National Mall: October 23 & 24, 2010
The Inaugural USA Science & Engineering Festival will be the country’s first national science festival and will descend on the Washington, D.C. area in the Fall of 2010. The Festival promises to be the ultimate multi-cultural, multi-generational and multi-disciplinary celebration of science in the United States. The culmination of the Festival will be a two-day Expo in the nation’s capital that will give over 500 science & engineering organizations from all over the United States the opportunity to present themselves with a hands-on, fun science activity to inspire the next generation of scientists and engineers.

Get involved now: join the over 400 organizations that have already signed up to host an Expo exhibit, become an official Festival Partner, organize a Satellite Event in your community, host a Festival Event, check out our cool school programs like Nifty Fifty and Lunch with a Laureate, volunteer, donate, become a sponsor, participate in one of several contests, buy a Festival T-shirt, follow our blog, and stay on top of it all by signing up for our bi-weekly e-newsletter. Will you be there when science takes over the National Mall?

THE A. JAMES CLARK SCHOOL of ENGINEERING
Summary

• Need to put the capital “E” back into STeM thru scalable partnerships
  – ASE Degree
  – Middle School/HS Outreach Programs
• Need to think about how to achieve an engineering experience for a larger number of high school students
  – Early College Program: Engineering Math
  – First Robotics
  – Project Lead the Way
  – Academy of Engineering
  – AP Class in Engineering
• Leverage partnerships between Government/Industry/Academia/Non-profit
  – Participate in USA Science and Engineering Day to raise visibility of STEM fields.
Thank You!