Engineering Education & Centers: An Integrative Role for the ENG Directorate

Spring 2014
ENG Advisory Committee Meeting

Theresa A. Maldonado
Division Director
Engineering Education & Centers
Engineering Education & Centers: An Integrative Role

- All Engineering disciplines

- ENG-wide roles (annual solicitations and program descriptions):
  - Engineering Education Research
  - Broadening Participation in Engineering
  - Research Experiences for Undergraduates
  - Research Experiences for Teachers
EEC Program Clusters

Centers & Networks
Engineering Education Research
Engineering Workforce Development
CENTERS AND NETWORKS
History: 1985 National Academies charged federal agencies to...

- Focus on fields to strengthen US competitiveness
- Increase engineering faculty committed to cross-disciplinary teams
- Focus on engineered systems
- Prepare creative, innovative engineers to influence US productivity
- Include industrial engineers as partners to stimulate technology transfer
NSF Response: Create the Engineering Research Centers program with the GOAL...

to “further the development of fundamental knowledge in engineering fields that will

• Enhance the competitiveness of the U.S. and

• Prepare engineers to contribute through better engineering practice.”
The ERC core elements have been sustained over time through three generations of the program.

- **Strategic vision** for transforming engineered systems
- **Research**
  - Systems-motivated, interdisciplinary, team-based
  - Societal-relevant, problem-focused
- **Education**
  - Interdisciplinary
  - Team-based
  - Global engagement
- **Technology/knowledge transfer**
  - Long-term university-industry-government partnerships
  - Mechanisms to accelerate innovation and technology transfer
- **People**
  - Community of scholar-educators
  - Diverse, globally competitive engineering workforce...
There are 17 active centers.
Gen-3 ERC: Small Business / ERC Collaborative Opportunity (SECO)
History of NSF funding from 1996 through to an ERC: USC – Biomimetic Microelectronic Systems ERC

- An external camera sends images to a microelectronic implant in the eye
- The implant stimulates the retina of a blind person to provide a sense of vision
- The retinal implant is commercially available in Europe and the US (FDA approved for clinical use)
- Current implants – navigation and letter reading
- Future implants – face recognition
ERC value-added in research and technology

CASA Tornado Warning Issued
3 minutes before official warning (NWS)
Real Time Warning Experiment with Foreencers

CASA Wind Vector products increase awareness of rotation

NWS Forecast Experiment
Manufacturers
Antenna/sensor manufacturers, Radar system manufacturers, end-to-end system integrators

Integrators

Early Adopters
Various users and beachhead customers

Customers
Economic customers (buyers) including federal agencies, foreign met. offices, municipalities

SECO Award #1246469 $200K
AIR Award #1237767 $1.3M
- CASA
- Stormwater Mgmt. Div City of Ft. Worth-$300K
- Nat. Weather Service-$275K
- Ft Worth Weather Forecast Office
- N. Central TX Council of Governments-$60K
- Ridgeline Instruments-$75K
- Ft Worth Emergency Mgmt. Operations-$56K
- UTexas-Arlington
- U North Texas
**Nanoscale Science & Engineering Centers (NSEC) Awards**

5-year awards via NSF-wide competition renewable for further 5 years

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cornell (CNS-IT)</td>
<td>Northeastern (CHN)</td>
<td>UC Berkeley (SINAM)</td>
<td>NWU and partner institutions</td>
<td>Arizona State (CNS)</td>
</tr>
<tr>
<td>Columbia (CETMN)</td>
<td>Ohio State (CANPBD)</td>
<td>Illinois (Nano-CEMMS)</td>
<td></td>
<td>UCSB (CNS)</td>
</tr>
<tr>
<td>Harvard (SNS-DA)</td>
<td>Penn (N/BI)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northwestern (CINDT)</td>
<td>Stanford (CPN)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rensselaer (C-DAN)</td>
<td>UC-Berkeley (COINS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice (CBEN)</td>
<td>Wisconsin (TSAN)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2006 Manufacturing UMass (CHM)</th>
<th>2008 Environmental Implications – Duke and UCLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008 Environmental Implications – Duke and UCLA</td>
<td></td>
</tr>
</tbody>
</table>

**NanoSystems ERCs**

**ASSIST:** NC State, lead Penn State, FIU, UVA, UNC-Chapel Hill

**NASCENT:** UT Austin, lead UC Berkeley, UNM

**TANMS:** UCLA, lead Cornell, UC Berkeley, Cal State Northridge

NNI is a national multi-agency initiative and an NSF-wide priority area. About a dozen NSF Divisions co-fund and co-manage NSECs.
New ERC competition is underway...

- 188 pre-proposals received
- 18 invited for full proposals
- Deadline: June 2014
- Awards in FY15

What will the future of the program look like? What role will it serve?
The Network for Computational Nanotechnology (NCN) is a powerful platform for nanoscale modeling and simulation research and education.

> 260K users globally

Re-competed in 2012

– Cyberplatform

– Two content nodes:
  • NEEDS (Nano-SPICE)
  • Nano-Bio

nanoHUB cited in 1,000+ papers (682 papers in North America)

2,019 authors

“nanoHUB builds an extraordinary community among different disciplines and industries involved in nanotechnology and allows them to collaborate more efficiently. It’s a virtual community that shows there are more solutions than there are problems.”

-Jack Udovich

Author of “The Most Valuable Thing is Really Small”
NCN impacts industry collaborations.

Demonstrates how nanoHUB facilitates the building of networks both within and outside of the NCN.

http://nanohub.org/groups/ncn/research#4
NCN Nano-Engineered Electronic Device Simulation (NEEDS) Node

NEEDS aims to create a complete model development environment (NEEDS-SPICE) to support the creation of high-quality compact models by technology developers and to provide designers with models that run robustly on both open source and commercial platforms.

Purdue University
MIT
UC-Berkeley
Stanford University (co-funded by SRC)
NCN nanoBIO Node

provide simulation building blocks and educational resources for use in nanoBIO device engineering. Building a new community which bridges engineering and biology through strategic partnerships and outreach activities.

University Illinois – Urbana Champaign
University California - Merced
STEM

FEDERAL SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) EDUCATION
5-YEAR STRATEGIC PLAN

A Report from the Committee on STEM Education
National Science and Technology Council

MAY 2013

http://www.whitehouse.gov/sites/default/files/microsites/ostp/steam_stratplan_2013.pdf

Humanities & Social Sciences

The Heart of the Matter
The Humanities and Social Sciences for a vibrant, competitive, and secure nation


Critical thinking, creativity, leadership, etc.

Technical Depth

Principles of STEM

Critical thinking, leadership, creativity, etc.
Improving Quality and Impact
Connecting Research to Practice

Complex Ecosystem
Multidisciplinary

Diversity of Pathways and Students
Agile, Dynamic & Rapid Adaptations to meet Demands of Society

Engineering Education Vision
<table>
<thead>
<tr>
<th>Program</th>
<th>Year</th>
<th>Number of Awards</th>
<th>Average Annual Amount</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Average Award Duration (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REE</td>
<td>2011</td>
<td>16</td>
<td>$284,884</td>
<td>$1,793,272</td>
<td>$16,525</td>
<td>2.42</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>22</td>
<td>$309,009</td>
<td>$769,110</td>
<td>$49,556</td>
<td>2.54</td>
</tr>
<tr>
<td>RIGEE</td>
<td>2011</td>
<td>12</td>
<td>$151,954</td>
<td>$179,440</td>
<td>$131,093</td>
<td>2.04</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>9</td>
<td>$147,778</td>
<td>$150,000</td>
<td>$133,293</td>
<td>1.99</td>
</tr>
<tr>
<td>Workshops</td>
<td>2010</td>
<td>5</td>
<td>$208,736</td>
<td>$79,927</td>
<td>$421,626</td>
<td>2.09</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>2</td>
<td>$45,019</td>
<td>$40,037</td>
<td>$50,000</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>3</td>
<td>$264,666</td>
<td>$290,996</td>
<td>$233,178</td>
<td>2.09</td>
</tr>
<tr>
<td>IEECI</td>
<td>2010</td>
<td>49</td>
<td>$213,815</td>
<td>$889,944</td>
<td>$20,241</td>
<td>2.76</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>6</td>
<td>$442,809</td>
<td>$466,681</td>
<td>$400,682</td>
<td>4.98</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>1</td>
<td>$400,000</td>
<td>N/A</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>CAREER</td>
<td>2010</td>
<td>4</td>
<td>$411,883</td>
<td>$443,576</td>
<td>$400,109</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>6</td>
<td>$442,809</td>
<td>$466,681</td>
<td>$400,682</td>
<td>4.98</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>1</td>
<td>$400,000</td>
<td>N/A</td>
<td>N/A</td>
<td>0.00</td>
</tr>
<tr>
<td>Innovation</td>
<td>2010</td>
<td>5</td>
<td>$1,320,052</td>
<td>$1,800,000</td>
<td>$600,000</td>
<td>2.89</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>14</td>
<td>$200,698</td>
<td>$210,000</td>
<td>$199,868</td>
<td>2.62</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>13</td>
<td>$188,691</td>
<td>$226,250</td>
<td>$50,000</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>11</td>
<td>$199,818</td>
<td>$200,000</td>
<td>$199,018</td>
<td>1.99</td>
</tr>
<tr>
<td>IREE</td>
<td>2010</td>
<td>1</td>
<td>$959,736</td>
<td>N/A</td>
<td>N/A</td>
<td>1.20</td>
</tr>
</tbody>
</table>
$10M for five years
EHR/DUE and ENG/EEC

National Center for Engineering Pathways to Innovation

What is the Epicenter?
The Epicenter is dedicated to infusing entrepreneurship and innovation skills into undergraduate engineering in the United States.

Funded by the National Science Foundation and directed by the Stanford Technology Ventures Program, the Epicenter is an education, research and outreach hub for the creation and sharing

Get Epicenter Updates

Email Address*
First Name
Last Name

Who are you? Check all that apply.

Epicenter: http://epicenter.stanford.edu/
National Collegiate Inventors and Innovators Alliance: http://nciia.org/
Professional Formation of Engineers

- Freshman
- Junior
- Sophomore
- MS Degree
- PhD Degree
- Senior
- "The Core"
- Industry
- Community Colleges
- Other Employment Sectors
- Licensure
- Public Values
- Faculty Development
- Research-to-Practice
- Internships
- K-12
- Maker Spaces
Are we approaching this complex adaptive engineering education system correctly when > 73% of ALL students enrolled in UG programs in the U.S. are non-traditional*?

*Nontraditional Student

- Delays enrollment
- Attends part time for at least part of the year
- Works 35 hrs. or more per week while enrolled
- Is considered financially independent (i.e., when determining financial aid)
- Has dependents other than a spouse
- Completed secondary education with GED or other certificate or did not finish high school

http://www.ere.net/2012/06/13/recruiting-the-73-nontraditional-students-must-be-part-of-your-plan/
ENGINEERING WORKFORCE DEVELOPMENT
The minority is becoming/has become the majority.

### States with the most minorities under age 1, 2011*

<table>
<thead>
<tr>
<th>State</th>
<th>Minority Percentage</th>
<th>Actual Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaii</td>
<td>85.5% (15,505)</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>75.1% (380,454)</td>
<td></td>
</tr>
<tr>
<td>New Mexico</td>
<td>75.0% (21,562)</td>
<td></td>
</tr>
<tr>
<td>Texas</td>
<td>69.8% (277,724)</td>
<td></td>
</tr>
<tr>
<td>Nevada</td>
<td>63.6% (23,336)</td>
<td></td>
</tr>
</tbody>
</table>

* The District of Columbia is 67.7% (6,041)

Source: U.S. Census Bureau

Robert Calzada/American-Statesman

Poverty increasing in public schools

Low-income students made up at least half the public school student population in 17 states in 2011, a marked increase from 2000, when four states topped 50 percent. Washington Post, 10/16/2013

“More college students battle hunger as education and living costs rise”
Washington Post, 4/9/2014

Growth in college food banks
The number of food pantries on college campuses has increased rapidly in the past six years — especially at colleges with a lot of low-income or first-generation students.

Number of college campuses that have started food banks after consulting with MSUSFB

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993-2007</td>
<td>1</td>
</tr>
<tr>
<td>2008</td>
<td>4</td>
</tr>
<tr>
<td>2009</td>
<td>9</td>
</tr>
<tr>
<td>2010</td>
<td>35</td>
</tr>
<tr>
<td>2011</td>
<td>64</td>
</tr>
<tr>
<td>2012</td>
<td>88</td>
</tr>
<tr>
<td>2013</td>
<td>117</td>
</tr>
<tr>
<td>2014</td>
<td>121</td>
</tr>
</tbody>
</table>

Source: Michigan State University Student Food Bank, Washington Post


U.S. demographics are experiencing accelerated shifts. Are we cognizant of these shifts as we focus on (meaningful and realistic) societal impact of research and education innovations supported by the Engineering Directorate?
Research Experiences for Undergraduates (REU)

...has inspired many students to continue their studies in Engineering and other STEM-related disciplines.

Research Experiences for Teachers (RET)

...has inspired many teachers to continue their professional development in STEM and make an impact in their classrooms.
## Engineering Workforce Development

<table>
<thead>
<tr>
<th></th>
<th>Number of Awards</th>
<th>Reviewed by Panel</th>
<th>Reviewed Ad-Hoc</th>
<th>Percentage of Ad-Hoc reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>REU</td>
<td>77</td>
<td>77</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>RET</td>
<td>26</td>
<td>23</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>BRIGE*</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>75%</td>
</tr>
</tbody>
</table>

* BRIGE ENG-wide
FY08-FY12: 153 awards
Award: $175K for 2 yrs.
ENG Broadening Participation

• Broadening Participation Program: May 1
• NSF Community
  – NSF employees
  – Panelists
• PI Community
  – Education
  – Building Relationships
• ERC
  – Formal review for education, diversity and outreach
• Social inequality (IUSE Ideas Labs)
• Engineering Databook
Internal strategy: Minimizing implicit bias in proposal evaluation

• What is *implicit bias*?
  – Hypotheses/stereotypes about a group, often about competence, may be implicit or unconscious
  – Accumulation of disadvantage
    • Small bias in same direction has large effect over time
    • Very small differences in treatment can have major consequences in salary, promotion, and prestige (*Valian, 1998*)

• Launched in EEC and a few programs elsewhere
• Will use for CAREER and other programs in ENG
The ERCs engage diverse leaders and teams.

What can we learn about the culture of centers that may positively impact diverse engagement and productivity in engineering research, education, and innovation?
EEC = The Integrator

- Education
- Research
- People
- Knowledge transfer and partnerships