Update on Engineering Education Activities

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Engineering Education at NSF

“Reform”

Capacity building for “Rigorous Research”

1980
Reagan eliminates NSF Education programs
1985
Nam Suh Neal Report
1990
Faculty Enhancement
Education Coalitions
1995
NSF Graduate Fellowships
2000
Eng Ed Schools
Lohman reshapes JEE
EC-2000 EGR of 2020
Eng Ed CAREER
2005
Engineering Education Research 2010
2010
Bridging Research & Practice
Coalitions (1990–2005)

Assessment (SRI, 1995):
- Local successes but not systemic reform
  - 10-25% increases in retention of first year students
  - GPA increased, time to degree decreased
  - 95% retention of minority students at Texas A&M
- Reform of first year curriculum
- Key role of learning communities and faculty engagement w/EER

Long Term:
- Producers and employers of engineering education researchers
- Role in ABET 2000 criteria (Lattuca/Penn State 2005):
  - More active learning, better student performance in communications, teamwork, and lifelong learning
  - 2004 graduates better prepared than 1994 counterparts BUT need more work on ethics, social context, diversity (climate worse in 2004 than 1994)
  - Scholarship of teaching not always valued in faculty reward structure

Purpose: Workforce needs and broadening participation
- $160M from ENG, teams of schools $2-3 M/yr for 10 yrs
- Together, schools enrolled 30% of US engineering students
Research in Engineering Education (REE) Program Description

• Pathways to and through engineering
• How credentials are earned and viewed
• Understanding the education innovation ecosystem
• Balance between technical and human
• How engineering is learned

Research Initiation Grants in Engineering Education (RIGEE) Solicitation

• Small, short term grants to build partnerships between engineering faculty and learning scientists
• Partnership focuses on a research project
• Anticipated outcome is continuation in REE program or other

Also: CAREER, STEP Epicenter (with EHR), workshops, INSPIRE, SAVI, etc.
Funding Allocations in EEC

$10 million/year

- Capacity Building (1/3-1/2)
  - CAEE, Midfield, iKNEER
  - 25 CAREER, 4 PECASE
  - Workshops
  - Bridging research to practice

- How Students Learn & How learning is measured (1/2-2/3)
  - Problem Solving
  - Design Thinking
  - Global Competencies
  - Creativity and Innovation

- Broadening Participation (1/3)
  - Design Squad
  - Veterans
  - STEP EpiCenter
Research in Engineering Education Portfolio Analysis

Types of projects funded

Populations targeted

Types of projects funded

- "Research"
- "Research > Intervention"
- Intervention
- Dissemination
- Workshop

Populations targeted

- K-12
- Undergraduates
- Graduates
- Faculty
- Pathways

% of Awards

- IEECI (2009-10)
- REE (2011-12)
So throughout the past year...

- AdCom Meeting, Spring 2012: Facilitated outside-the-box discussions w/ Dr. Roger Burton
- August 2012: small (intense) meeting to explore future directions for the ENG Education discipline
- AdComm Meeting, Fall 2012: Panel discussion – Alan Cheville (ENG), Don Millard (EHR), and Daniel Hastings (edX, MIT)
- Cheville: Comprehensive strategy for the future
- New hire: Dr. Donna Riley
Vision

Initiate and nurture discoveries and innovations that inform an engineering education system that can dynamically and rapidly adapt to meet the changing needs of society and the nation’s economy, is equally accessible to all members of society, and constantly improves the quality and diversity of graduates ready to enter the technical workforce.

Transform Frontiers
Innovate for Society
Perform as a Model Organization

- Improving Quality and Impact
- Connecting Research to Practice
- Complex System Ecosystem
- Multidisciplinary
- Diversity of Pathways and Students
- Agile, Dynamic & Rapid Adaptations to meet Demands of Society
Future Directions and Challenges

National policy context: emphasize the “E” in STEM

Long-term plan: to guide agile responses to changing needs

Systems
“engineer” engineering education

Cognitive and Learning Sciences

Access Equality and Affordability
Future Directions and Challenges

- Shift focus to opportunities for structural change
- Scale up using a successful NSF model like PREM
- Better tools and products
- Demand side?

- Strong need for faculty development -> reward structures
- EFRI finalist: Engineering Education as a Complex System

**Structures**
- Systems
  - “engineer” engineering education

**Cognitive and Learning Sciences**

**Access Equality and Affordability**
Future Directions and Challenges

- How do engineering students learn and integrate social context?
- How do we assess student learning in/of context?
- NSF gap in funding undergraduate ethics education
Future Directions and Challenges

Broaden Participation
- Who is studied?
- Who does the studying?
- EER can provide structural focus

Cognitive and Learning Sciences

Systems “engineer” engineering education

Access Equality and Affordability

Program Participation
What is research in engineering education?

Research Questions
A few focused and limited questions the study is trying to answer.

Theoretical and Methodological Frameworks
What theory informs research questions and gives insights into the results? What research methodologies are appropriate to the questions?

Methods
Clear, theoretically informed process for data collection and analysis.
Impact: Improving Student Learning

- Gamechanger: Pedagogical practices can nurture creativity
- Valid instrument for measuring creativity and propensity to innovate, propagated in ERCs
- Index for global competencies used at 17 universities (includes ethics, engineering efficacy, connectedness of engineering communities)
Massive Open Online Courses (MOOCs)

Dorothy Jones-Davis, AAAS S&T Policy Fellow

- **Educational Disruption**
  - Challenges traditional models of knowledge dissemination, and the role of the instructor
  - Provides an opportunity for gaining a deeper knowledge of the process of learning, for engagement of student populations traditionally underrepresented in Engineering
  - Massive Open Online Courses (MOOCs) are an example of a recent educational disruption that has started a revolution, and for some, a revolt
History of MOOCs at NSF

- MOOC “precursors” in ENG
  - Network for Computational Nanotechnology (NCN)/NanoHUB
  - Ethics Education in Science in Engineering (EESE)/Ethics Core
- October 2012: MOOCs and Disruptive Technologies in Education AAAS Fellow Working Group (MaDTECHEd)
- December 2012: NSF Internal Workshop on MOOCs (EHR/ENG/CISE/SBE MaDTECHEd AAAS Fellows)
- Approximately 100 participants, representing all directorates, and a majority of divisions within NSF
- January 2013: PD-level agency-wide “working group” formed by EHR

Funded MOOC-related Grants as of 4/1/13 (n = 8)

- EHR 50.0%
- CISE 25.0%
- ENG 12.5%
- OD 12.5%
- GEO 0.0%
- SBE 0.0%
- MPS 0.0%
- BIO 0.0%
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Pending MOOC-related Grants as of 4/1/13 (n = 96)
Preparing the Engineer for the Future

National need: To stimulate and accelerate U.S. economic growth and global competitiveness by preparing more engineering undergraduate and graduate students for practice in the private and/or public sectors.

- **Strengths**
  - Growing body of knowledge in ENG education research
  - Growing community of ENG education researchers
  - Growing interest by industry

- **Weaknesses / Challenges**
  - Gap between research & practice
  - Skills gap between ENG preparation of students and industry expectations
  - (Very weak) transition points
  - Interactions between scales
  - (Serious lack of) diversity of engineering students, faculty, and the workforce
  - (Relatively poor) level of Funding for ENG education research and practice

- **Opportunities**
  - (Internal) Joint strategies specific to ENG education with EHR, SBE, & others
  - (Internal) Joint strategies specific to broadening participation in ENG with EHR, SBE, & others
  - (Internal) NSF centers as platforms for demonstrating ENG education research outcomes and research training of students
  - (External) Partnership with Dept. of Education specific to ENG
  - (External) Public – private partnerships with industry and non-profits

- **Threats**
  - (Accelerated) Waning of U.S. global competitiveness
  - Regional economic decline
Opportunities for EER in ENG

Why ENG?
- Connected to the discipline and its specific needs
- Adjacent to research
- Lends important credibility, supporting change efforts
- Guards against risk of “losing the E in STeM”
- Nam Suh: responsibility of ENG to do education

What can ENG do?
- Nurture a Directorate wide working group
- Strategy for messaging within ENG divisions and engineering disciplines

Whither EHR?
- History of collaboration, esp. on large projects
- Programs are different (disciplinary tradition and OMB requirements affect scope and scale)
- We need to align differences & our messaging about them with our strategic goals
Looking Forward

Opportunities and Challenges

- MOOCs & online coursework represent an OPPORTUNITY
  - To ease entry into Engineering fields, particularly for key groups (Veterans, LIFG, URM, persons with disabilities)
  - To address workforce needs (e.g. Power, Energy, Nuclear, Aerospace)
  - To ask Engineering-specific research questions surrounding learning in online environments
    - How do engineering students learn in the context of MOOCs?
    - How can we leverage online learning to enhance project-based learning?
    - How can we design online learning to work with engineering needs (design components, team-based learning)?

- Challenges
  - Adaptation to discipline-specific course needs
  - Validation of learning outcomes
  - Accreditation
What questions should we be asking?