Professional Formation of Engineers

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ENG Advisory Committee Meeting

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Professional Formation of Engineers (PFE)

• What is it?
  - Processes by which people become engineers
  - Includes but is not limited to formal education - Unites informal, formal, and non-education activities

• Why support PFE?
  - Ethical duty of existing engineers to sustain and grow the profession
  - Perennial calls for holistic engineers with a broad set of professional abilities

• What are some elements of PFE?
  - Introductions to the profession at any age
  - Cultivation of the desire to make a difference
  - Acquisition of technical AND professional skills, knowledge, & abilities in formal and informal settings (preK-gray)
  - Development of outlooks, perspectives, ways of thinking, and ways of doing
  - Acculturation to the profession, its standards, and norms
  - Development of identity as an engineer
EEC Goals for Professional Formation

- **Build capacity for research** in Professional Formation of Engineers
- **Understand change processes** in the engineering education-workforce ecosystem
- **Strengthen “target points”** in the engineering education-workforce ecosystem
- **Increase welcome and access** for groups underrepresented in the engineering profession
EEC Undergraduate Strategy for PFE

• REE – open funding of best ideas in engineering education (including but not limited to undergraduate)
• FY 14: IUSE Ideas Lab on Social Inequality in Engineering
• Other Ideas for Undergraduate Engineering Education:
  – Generate new knowledge for **holistic professional formation of engineers**
  – Generate new knowledge on how to **incentivize faculty development and build department cultures** that support the holistic professional formation of engineers
What informs the undergraduate strategy?

- Past success in first year and senior year – need now to focus on middle years and technical core courses
  - Attrition is high especially in sophomore year
  - Critical entry point for transfer students
  - Need to integrate professional skills holistically across undergrad experience

- Prior research points to the following needs:
  - Faculty development
  - Faculty reward systems
  - Cultures that support faculty engagement

- Department Head leadership as lever for change
Example PFE “target point”: the Core

PhD Degree
MS Degree

Industry

Senior

“The Core”
Junior
Sophomore

Freshman

Community Colleges
Example PFE “target point”: the Core

- Department
- Head Role
- PhD Degree
- MS Degree
- Public Values
- Industry
- ABET
- Licensure
- Other Employment Sectors
- Community Colleges
- Innovation
- Faculty Development
- Internships
- K-12
- Maker Spaces
- "The Core"
  - Senior
  - Junior Sophomore
  - Freshman
  - "The Core"

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Role of R&RA Directorates in Improving Undergraduate STEM Education (IUSE)

Disciplinary based implementation and scaleup

The Innovation Cycle of Educational Practice and Research

Educational Practice

which help improve

Answers Insights

that results in

Educational Research

identifies and motivates

Questions Ideas

which lead to

Disciplinary based incubation

Adapted from Booth, Colomb, and Williams, 2008
PFE More Broadly

• Some possible priority areas:
  o Professional formation in master’s programs
  o Translational experiences for US grad students (experience abroad, integrate in home lab)
  o Pathways to Professional Engineer (PE license) – 2 year, 4 year, apprenticeships, credentialing, etc.
  o Professional formation in 2-year degree programs
  o How early introductions define engineering (e.g., opportunities with Next Generation Science Standards (NGSS), GK-12-like activities, maker spaces, informal encounters with engineering)

• Would a prize be an effective tool?

• Other cross-division and cross-directorate partnerships/collaborations:
  ➢ Strengthening outreach efforts, bringing coherence, best practices across CAREER, ERCs, and other awards...
  ➢ Professional formation for public engagement – strengthening broader impacts through faculty development
Research Questions

• How are K-12 engineering standards being implemented in mathematics and science classrooms?
• Do teachers introduce engineering through content or context, and what are the advantages/disadvantages of each?
• How do teachers’ perceptions of the individual STEM disciplines and the integration of these disciplines change over time?
• What forms of teacher professional development are effective in supporting the implementation of the K-12 engineering standards?

Methods

Mixed methods, multiple-case, embedded case study design that employs a variety of data sources in order to fully understand teachers’ implementation strategies and obstacles as they work to address engineering standards in the K-12 classroom.

Theoretical Framework

Develop a theory about teaching engineering within mathematics and science courses that weighs the merits of context (motivation and self efficacy) and content (cognition).
Framework for Quality Engineering Education

I. Process of Design
II. Apply Science, Engineering, and Mathematics Knowledge
III. Engineering Thinking
IV. Conceptions of Engineers & Engineering
V. Engineering Tools & Processes
VI. Issues, Solutions, Impacts
VII. Ethics
VIII. Teamwork
IX. Communication

Follow-on $8M Math-Science Partnership

EngrTEAMS: Engineering to Transform the Education of Analysis, Measurement, and Science in a Team-Based Targeted Mathematics-Science Partnership
Questions

• Does PFE open up new ways of thinking?
• What is the proper role for ENG in the PFE space?
• How do we ensure that our investments align with emerging issues in K-12, higher education, and industry?
• What should our expectations be for what we can achieve with our investments? How can we maximize impact?
The emerging PFE Landscape

IUSE

REE

Dept Focus

PFE