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

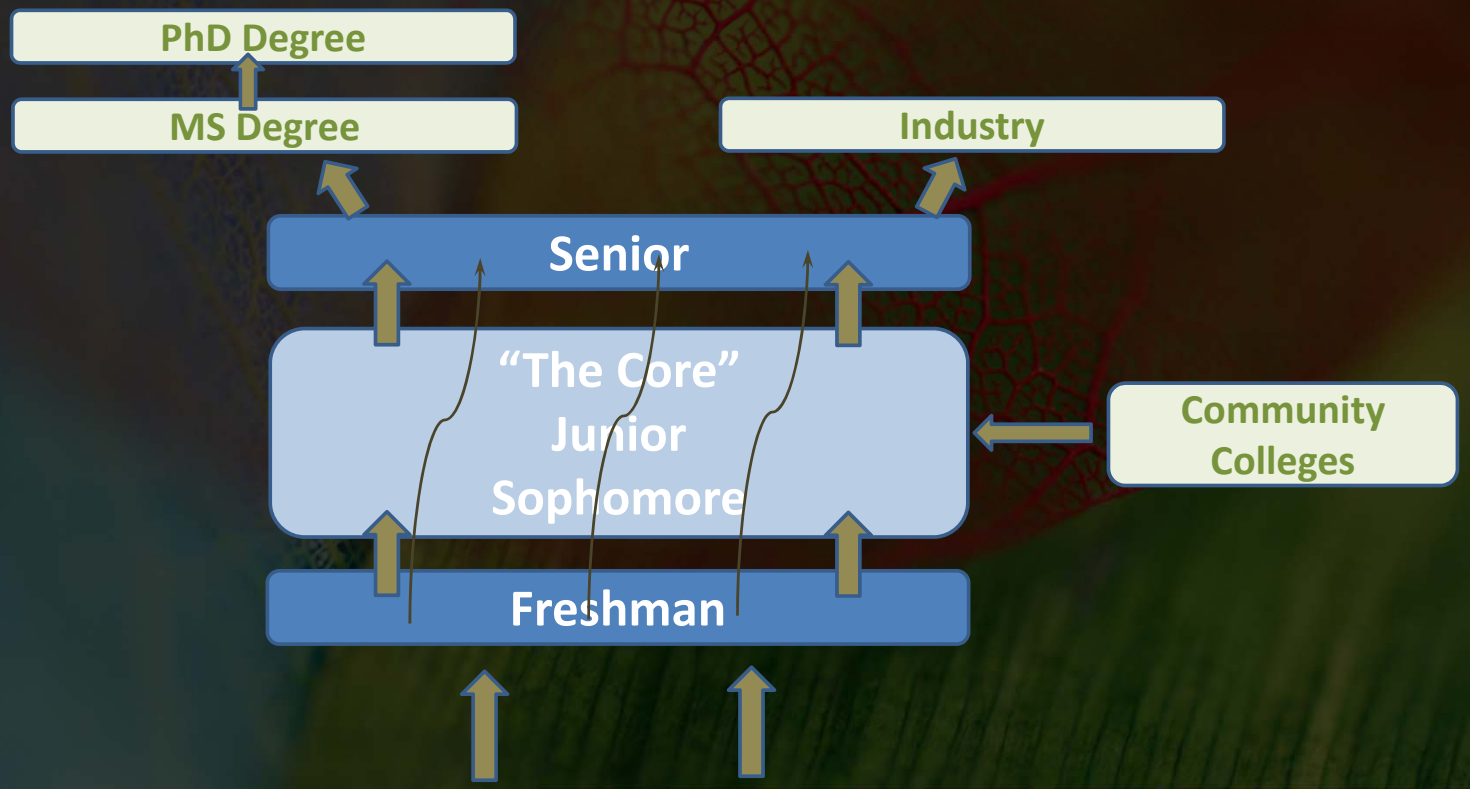
EEC Undergraduate Strategy for PFE

- 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



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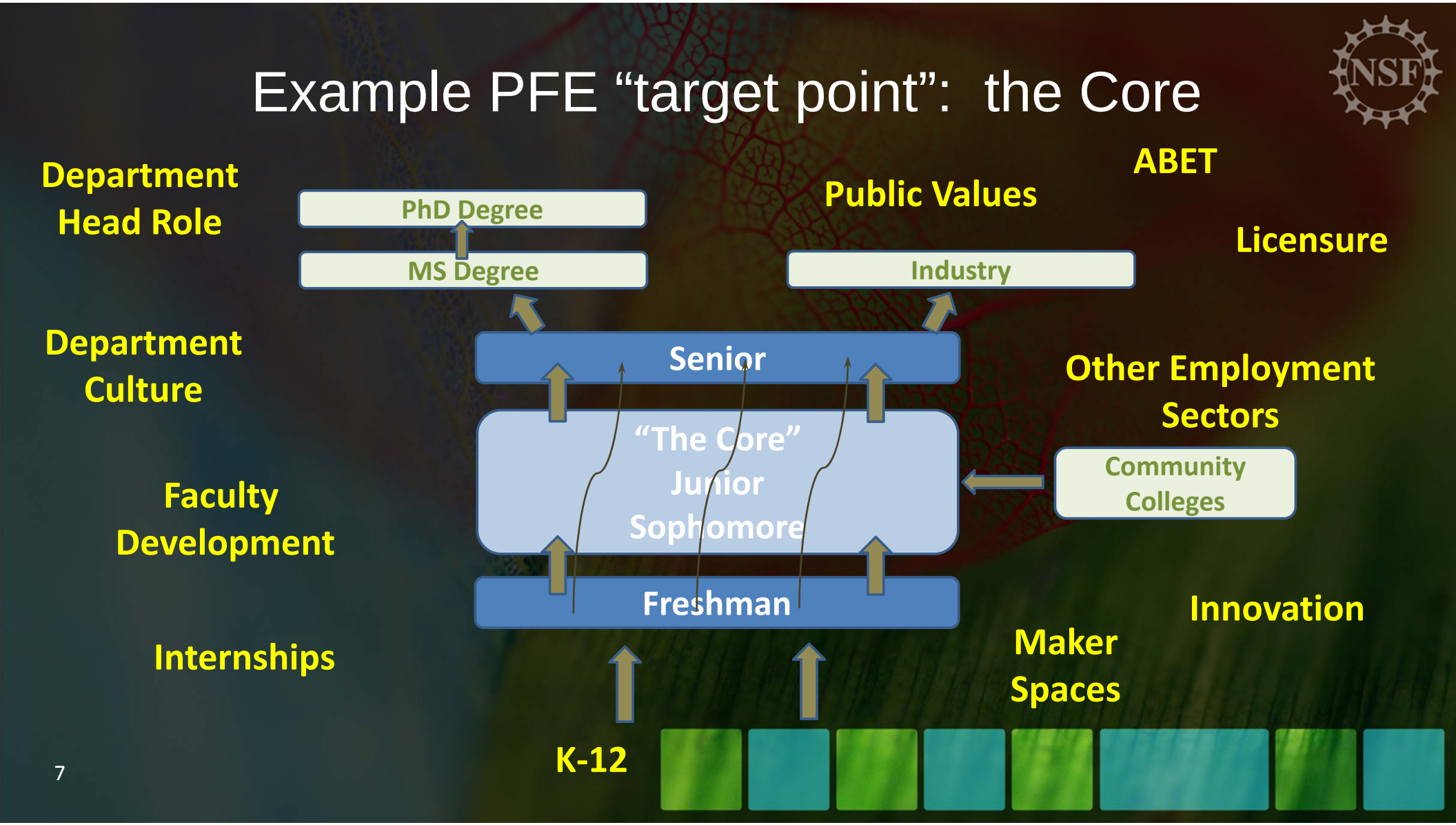
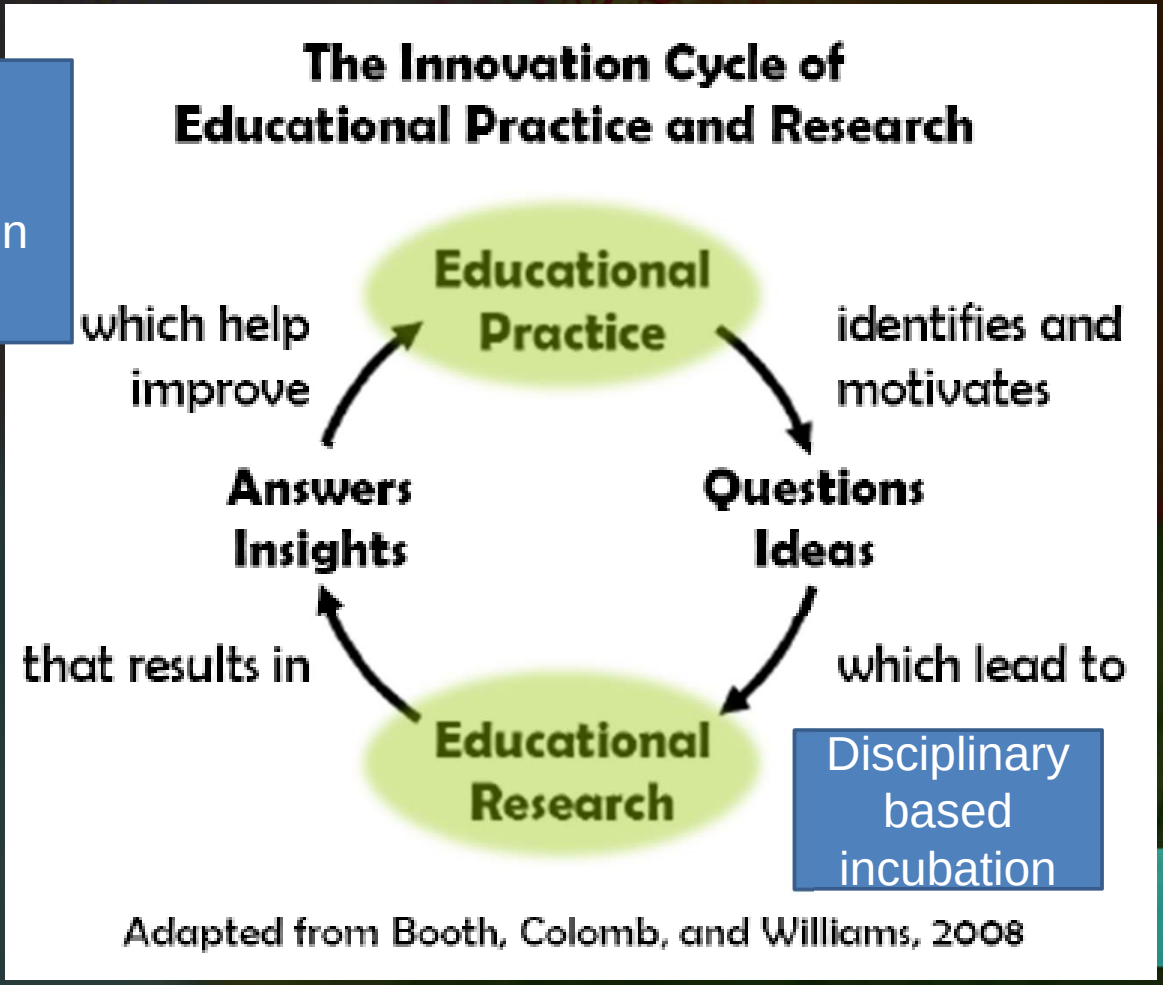


Role of R&RA Directorates in Improving Undergraduate STEM Education (IUSE)

Disciplinary based implementation and scaleup



Disciplinary based incubation

PFE More Broadly

- Some possible priority areas:
  - Professional formation in master's programs
  - Translational experiences for US grad students (experience abroad, integrate in home lab)
  - Pathways to Professional Engineer (PE license) – 2 year, 4 year , apprenticeships, credentialing, etc.
  - Professional formation in 2-year degree programs
  - 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

Tamara Moore
PECASE
U Minn

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?

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).

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

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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