ENGINEERING AND EDUCATION: SYNERGIES AND OPPORTUNITIES

Joan Ferrini-Mundy
Assistant Director, National Science Foundation
Education and Human Resources

Advisory Committee, Directorate for Engineering
April 23, 2014

Key Areas for Collaboration:

- Improving undergraduate education
- Broadening participation in engineering careers
- Understanding engineering learning through research

IMPROVING UNDERGRADUATE EDUCATION

National Science and Technology Council Committee on STEM Education, *Federal STEM Education 5-year Strategic Plan*, May 2013

Five national goals to drive Federal investment in five priority STEM education investment areas:

- Enhance STEM Experience of Undergraduate Students: Graduate one million additional students with degrees in STEM fields over the next 10 years.

Strategic Objectives for Undergraduate Priority Area

- Implementation of evidence-based practices and infrastructure to improve empirical understanding of relationship to student outcomes
- Support at 2-year colleges and for bridges from 2 to 4-year colleges
- University industry partnerships and research experiences
- Introductory mathematics courses

NSF Internal Activity, FY 2013-2014

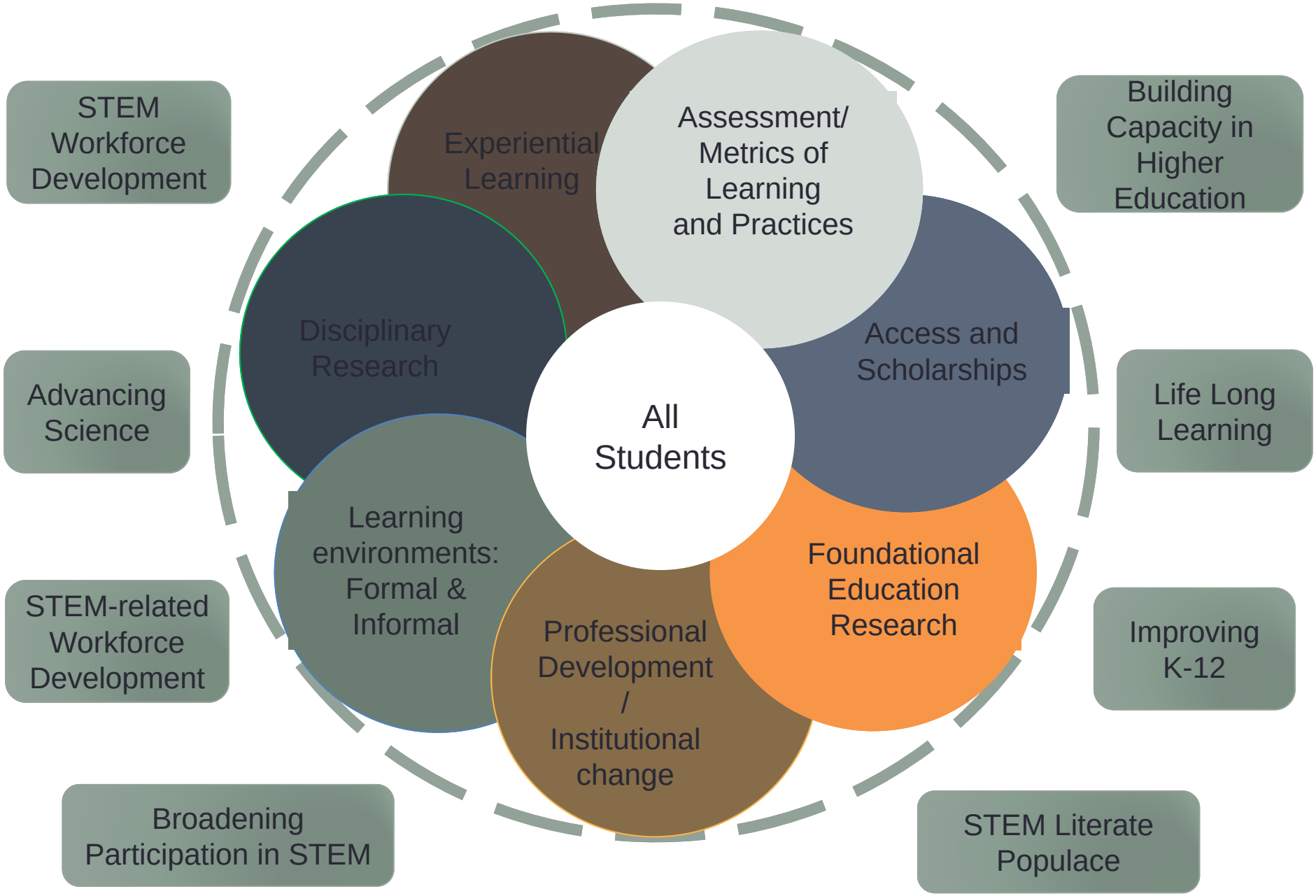
- NSF-Wide Undergraduate Framework Design Team, fall 2013: completed ***Proposed NSF Framework for Undergraduate STEM Education***

- Directorate-specific transition activities (EHR, GEO, ENG, BIO)

  EHR: IUSE program description, including Ideas Labs calls with BIO, ENG, and GEO

- NSF-Wide Undergraduate Implementation Team 2014: developing 5-year roadmap, elaborating the framework, and hosting NSF-wide conversation

Scope of Undergraduate STEM Education



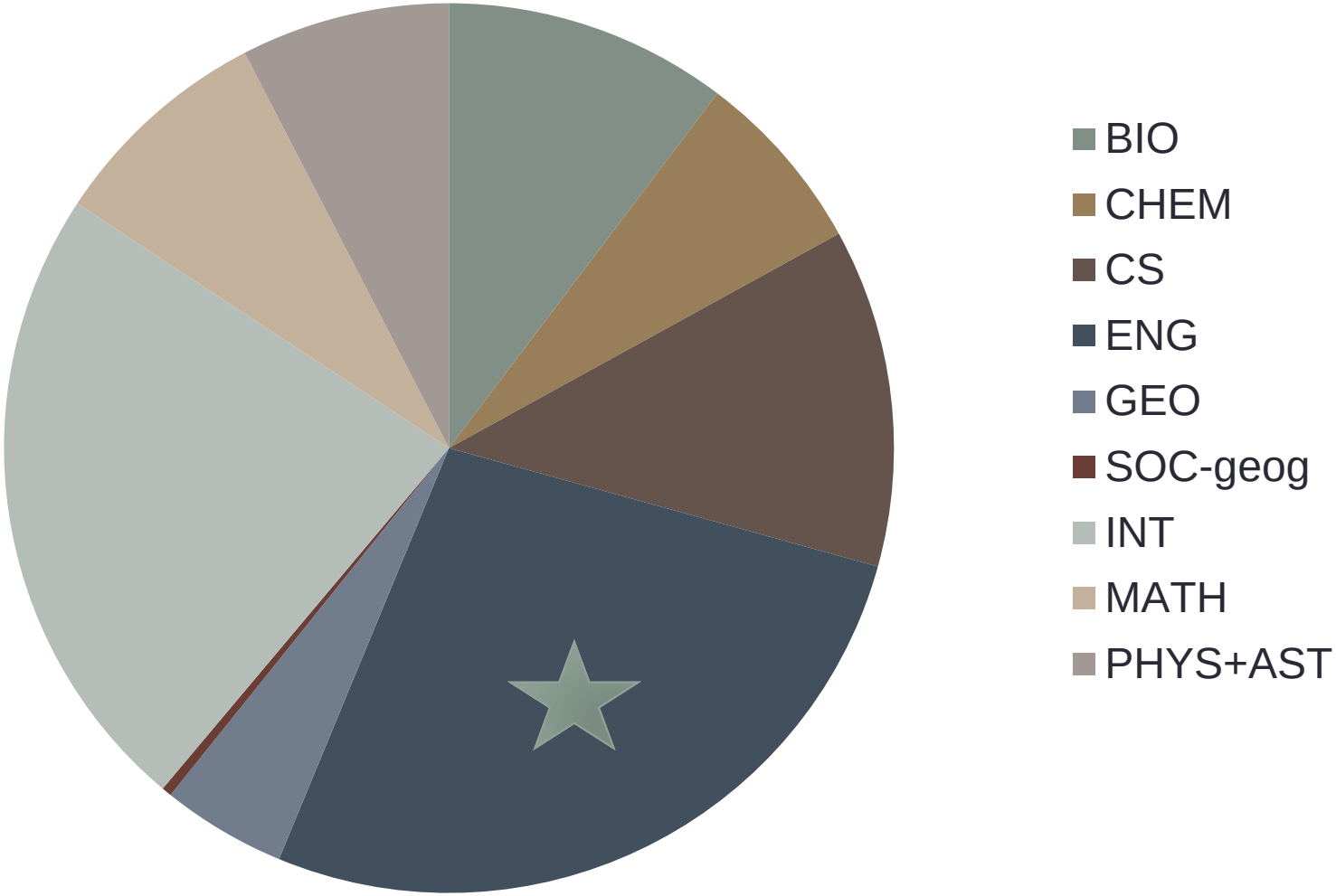
Improving Undergraduate STEM Education (EHR Program Description 14-7513)

- Target date for proposals: February 4, 2014; proposals can still be submitted up to early May for consideration

- Includes three Ideas Labs held in March (biology, geosciences, and engineering)

EHR IUSE: Distribution of Proposals

Discipline-Oriented N = 553



Engineering Phase I Ideas Lab

March 17-21, 2014: 30 participants (287 applicants)

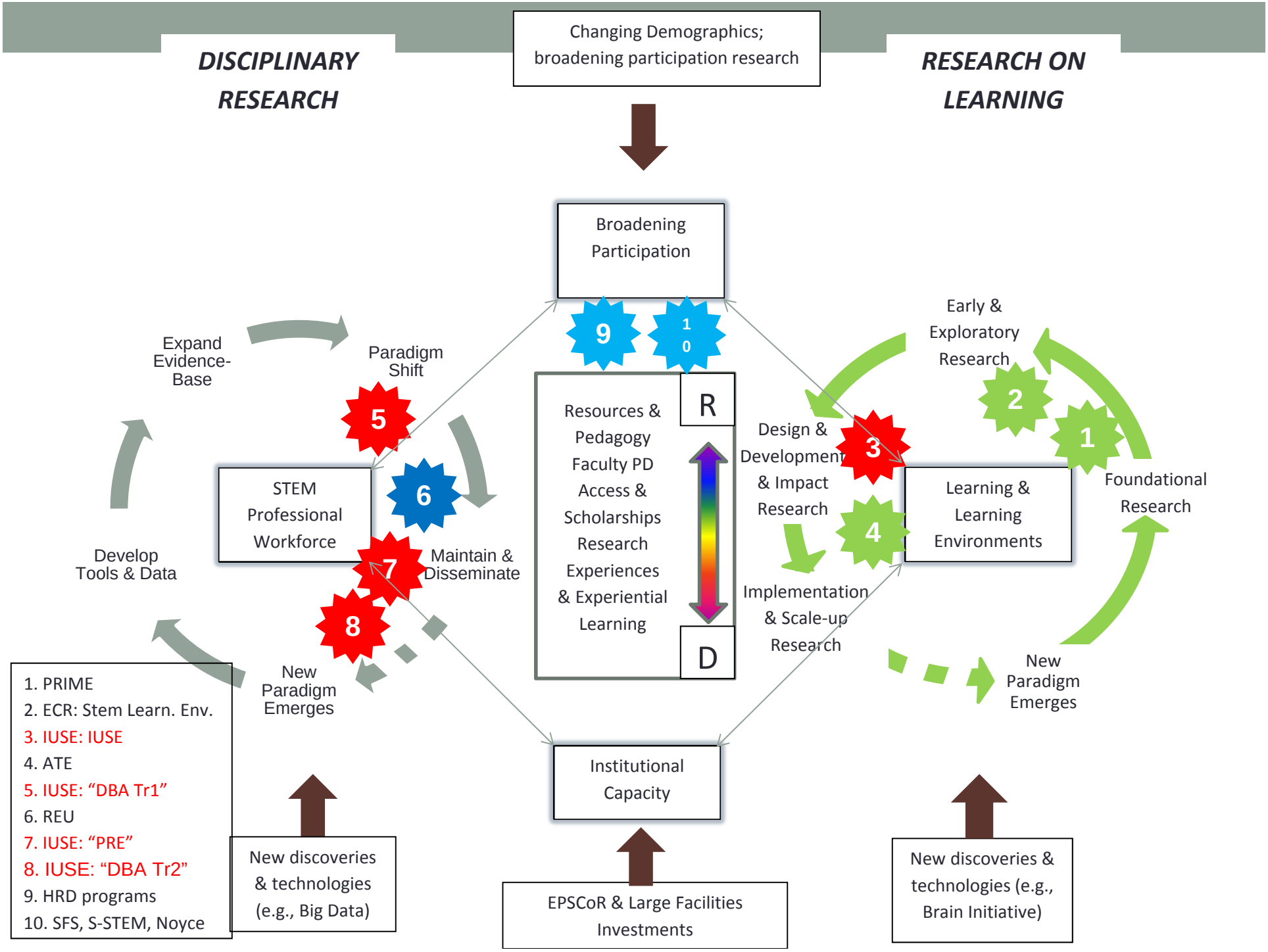
Grand Challenge: Social inequality in engineering education and practice is a durable problem, one that has resisted perennial efforts to “broaden participation,” “increase diversity,” or “improve recruitment and retention of women, minorities, and people with disabilities.” Engineers and social scientists will face head on the systems and structures that reproduce social inequality in engineering education and in the engineering workforce.

Charge to IUSE Implementation Team

- Undertake the FY 2014 NSF Undergraduate STEM Education Performance Goal
- Develop a management plan for the NSF investment in undergraduate education for FY 2015
- Develop a 5-year roadmap for the NSF investment in undergraduate education

Four Pillars: Long-Term Goals

- Learning & Learning Environments
  - Improve the knowledge base for defining, identifying, and innovating effective undergraduate STEM education teaching and learning for all disciplines.
- Institutional Capacity
  - Build institutional capacity to use and generate evidence-based resources and practices for effective undergraduate STEM education that integrate STEM research, teaching, and learning.
- Broadening Participation
  - Increase the number and diversity of undergraduate students recruited and retained in STEM education and career pathways.
- STEM Professional Workforce
  - Prepare undergraduate students to be productive members of the future STEM workforce and all students to be STEM-literate citizens.


DISCIPLINARY RESEARCH
Changing Demographics; broadening participation research
RESEARCH ON LEARNING
Broadening Participation
9
10
Resources & Pedagogy Faculty PD Access & Scholarships Research Experiences & Experiential Learning
R
D
Expand Evidence-Base
Paradigm Shift
5
STEM Professional Workforce
6
Develop Tools & Data
7
Maintain & Disseminate
8
New Paradigm Emerges
Early & Exploratory Research
2
1
Foundational Research
Design & Development & Impact Research
3
4
Learning & Learning Environments
Implementation & Scale-up Research
New Paradigm Emerges
1. PRIME
2. ECR: Stem Learn. Env.
3. IUSE: IUSE
4. ATE
5. IUSE: "DBA Tr1"
6. REU
7. IUSE: "PRE"
8. IUSE: "DBA Tr2"
9. HRD programs
10. SFS, S-STEM, Noyce
New discoveries & technologies (e.g., Big Data)
Institutional Capacity
EPSCoR & Large Facilities Investments
New discoveries & technologies (e.g., Brain Initiative)

FY 2015 Budget Request, IUSE

- IUSE Framework will eventually accommodate all NSF investments in undergraduate education and will be aligned with agreed-upon, cross directorate goals and outcomes.
- Aligned with the funding strategy will be the development of robust, common indicators and metrics to gauge progress toward the goals of IUSE.
- Common names/ subtitles
- Respect disciplinary needs and emphases
- Continued agency-wide efforts at coordination and coherence
- EHR in lead role for coordination

I-Corps for Learning (I-Corps-L)

- A pilot initiative to study whether the I-Corps model can help to propagate and scale educational innovations

- I-Corps guides teams using established strategies for business start-ups, using the Business Model Canvas and the Lean LaunchPad tools, to build entrepreneurial skills that will encourage mainstream application of their emerging technologies

I-Corps-L Goals

- Improve the teaching and success rates of students in key STEM courses by helping to accelerate the process of bringing effective educational innovations to scale
- Offer an experiential learning opportunity to help determine the readiness of an innovation for sustainable scalability
- Develop a transition plan and actionable tasks to move the innovation forward to sustainable scalability
- Foster an entrepreneurial mindset within the education community to impact the way innovations are designed and implemented

BROADENING PARTICIPATION

Assumption:

By including engineering and design in K-12 education, more students, and more students from groups that are underrepresented in engineering, will pursue engineering majors at the undergraduate level.

Open questions, K-12:

- Can engineering and design content be used to help students learn standard mathematics and science content?
- What kind of K-12 engineering learning experiences help attract diverse students into engineering?
- What policy changes are needed to incorporate engineering education in K-12?

NEXT GENERATION SCIENCE STANDARDS

DESIGN SQUAD

EiE Engineering is Elementary®
Developed by the Museum of Science, Boston

CompuGirls

Pathways Into Diversity and Inclusiveness

Retention and Persistence of Women and Minorities Along the Engineering Pathways in the United States *

Gary Lichtenstein, Helen L. Chen, Karl A. Smith, and Theresa A. Maldonado

Social Justice and Inclusion: Women and Minorities in Engineering *

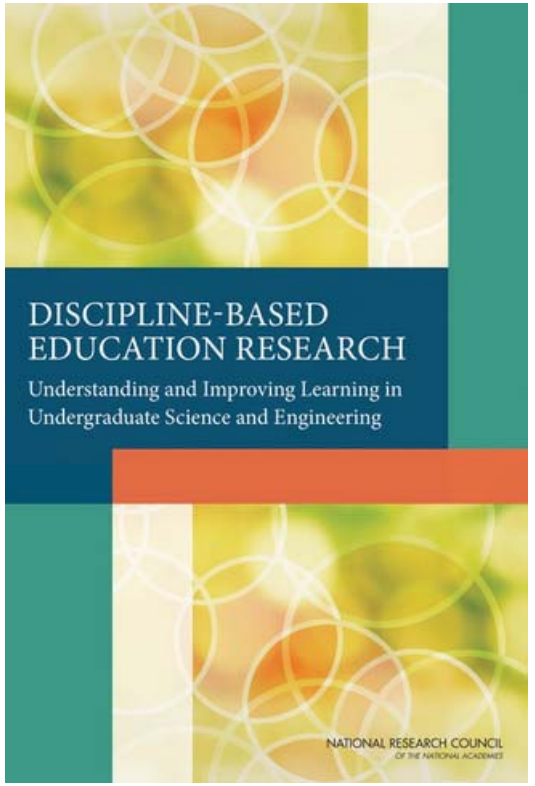
Donna Riley, Amy E. Slaton, and Alice L. Pawley

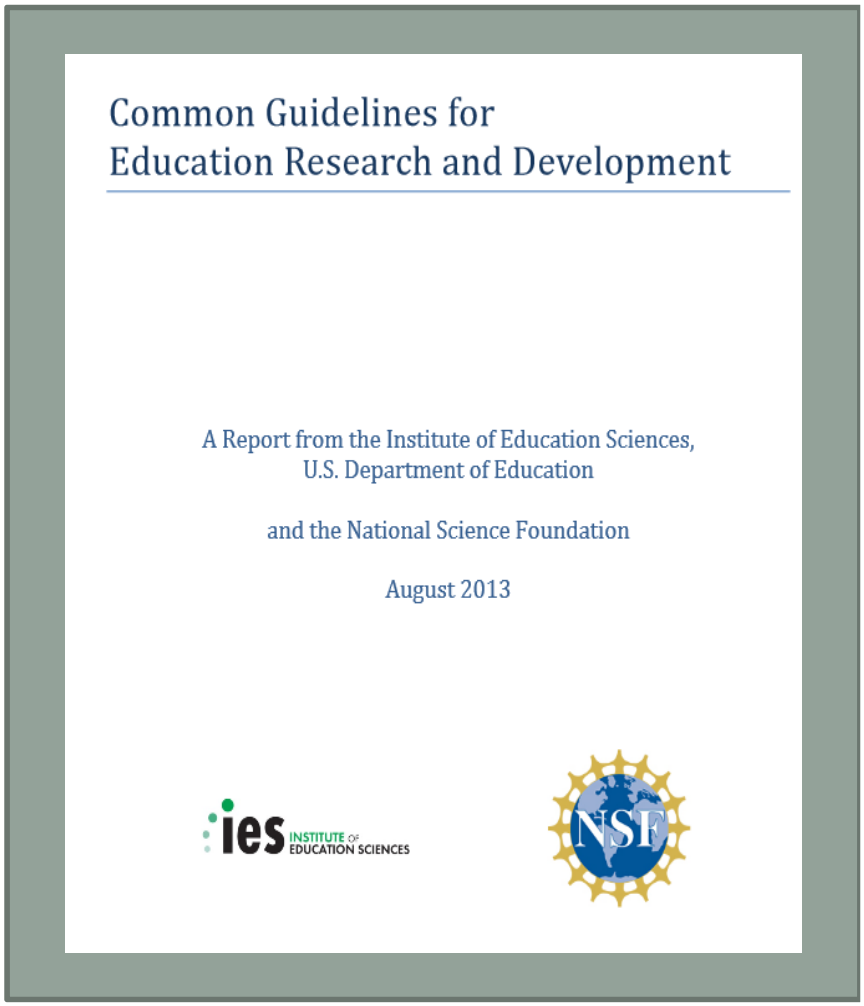
* In *Cambridge Handbook of Engineering Education Research,* edited by Aditya Johiri and Barbara M. Olds

UNDERSTANDING ENGINEERING LEARNING THROUGH RESEARCH

Discipline-Based Education Research

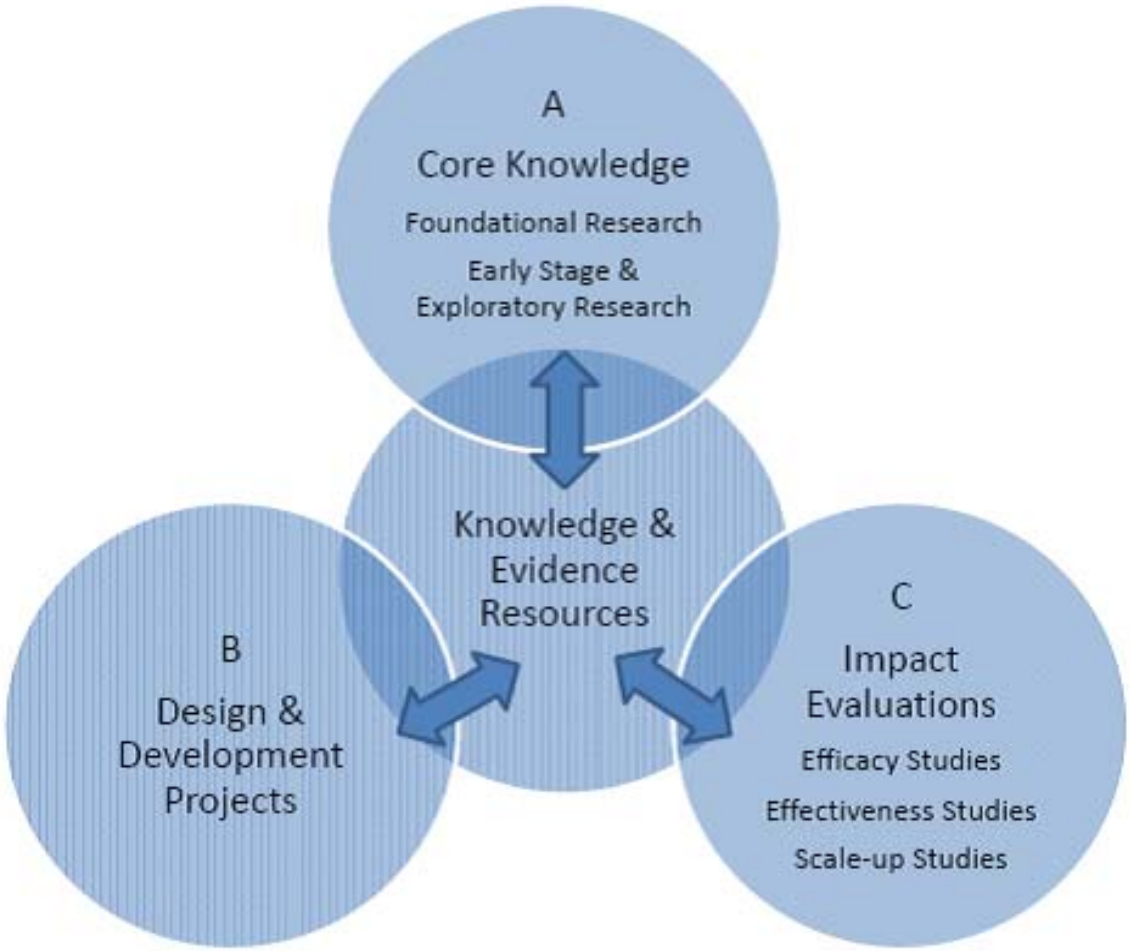
"For engineering students, the difficulty also can manifest itself as dependence on ritualistic algorithmic problem solving rather than true understanding, sometimes resulting in the inability of the student to even recognize the problem." (p. 84)





http://www.nsf.gov/pubs/2013/nsf13126/nsf13126.pdf

"…began work to establish cross-agency guidelines for improving the quality, coherence, and pace of knowledge development in science, technology, engineering and mathematics (STEM) education. The committee formed to enhance the efficiency and effectiveness of both agencies' STEM education research and development programs…" (p. 4)


A
Core Knowledge
Foundational Research
Early Stage &
Exploratory Research
Knowledge &
Evidence
Resources
B
Design &
Development
Projects
C
Impact
Evaluations
Efficacy Studies
Effectiveness Studies
Scale-up Studies

Thank you!

Joan Ferrini-Mundy
jferrini@nsf.gov