What *IS* Rigorous Research in Engineering Education?

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Overview

- Welcome and introductions
- Background about engineering education research
  - Global landscape
  - RREE projects in US
- What IS rigorous research in engineering education
  - Compare and contrast with technical engineering education
  - Global considerations
- Format
  - Interactive
  - “Team” based

Who’s Here

- Introduce yourself
  - Name, Institution, Country, Discipline, etc.
  - Engineering education research experience
  - Expectations/goals for the session
    - What would make this more useful and valuable for you?

Our Characteristics

- Geographic location
- Discipline
- Position – faculty, administrator, researcher, student
- Institutional support for engineering education research
- Engineering education research
  - Involved graduate students
  - Published engineering education articles, conference papers
  - Funding
- Collaborated with social scientists or educators

Workshop Framing

- Workshop is about
  - Deepening understanding of engineering education research
  - Building engineering education research capabilities
  - Identifying and recognizing faculty interested in doing engineering education research
- Workshop is NOT about
  - Pedagogical practice, i.e., “how to teach” seminar
  - Convincing you or your colleagues that good teaching is important
  - Writing engineering education research grant proposals
  - Insisting that all faculty become engineering education researchers

Engineering Education Levels of Inquiry

- Level 1: Effective Teacher
- Level 2: Scholarly Teacher
- Level 3: Scholarship of Teaching and Learning (SoTL)
- *Level 4: Engineering Education Research*

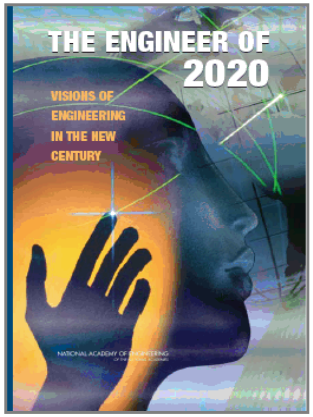
1. Streveler, R., Borrego, M. and Smith, K.A. 2007. Moving from the “Scholarship of Teaching and Learning” to “Educational Research:” An Example from Engineering. *Improve the Academy,* Vol. 25, 139-149.

Global Landscape

Jack R. Lohmann, Vice Provost and Professor, Georgia Tech,
and Editor, *Journal of Engineering Education*

Wanted:

The Global Engineer



Understand…

- complex systems
- new materials
- information systems
- multi-disc. design
- global markets
- business practices
- social considerations
- political contexts
- safety
- sustainability
- manufacturability
- reliability
- maintainability
- and…

Be…

- culturally sensitive
- socially aware
- politically astute
- broadly knowledgeable
- lifelong learner
- team player
- effective communicator
- speak foreign languages
- ethical
- innovative
- entrepreneurial
- flexible
- mobile
- and…

Can engineering programs really instill all this!?

And if we could….

an international dilemma

- **Who will be there to teach?**

  Enrollments are “soft” in developed countries, students see opportunities in other fields

- **How to handle those that are?**

  Enrollments are rising rapidly in developing countries, often outstripping their capacity

How should we respond?

educational innovation based on R&D

Reform-based model

- **Model:** Innovation based on reflection, experience, intuition
- **Pro:** Generally well-connected to both engineering and teaching practice
- **Con:** Inefficient in discovery, sometimes duplicative, transferability problematic

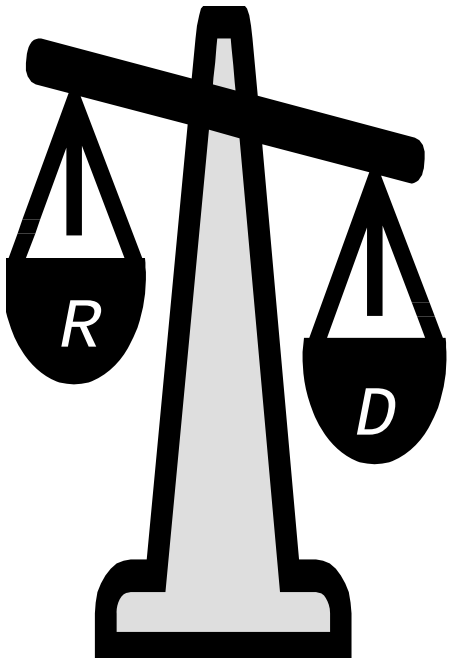
Research-based model

- **Model:** Innovation based on scholarly educational research
- **Pro:** More efficient in discovery, less duplicative, generally transferable
- **Con:** Can become disconnected from engineering and teaching practice; not many engineering faculty can or will become educational researchers

Research and Development (R&D)-based model

- **Model:** Innovation based educational researchers and practitioners working collaboratively in continuous cycles of educational research and development
- **Pro:** Mutually leverages the “pro’s” of the reform- and research-based models
- **Con:** Jointly diminishes the “con’s”

The challenge
an imbalanced portfolio



- Engineering educational development is a more mature field than engineering educational research…
- …there is a need to advance the global capacity for **engineering educational research** to better leverage engineering education development and, thus, accelerate engineering education innovation

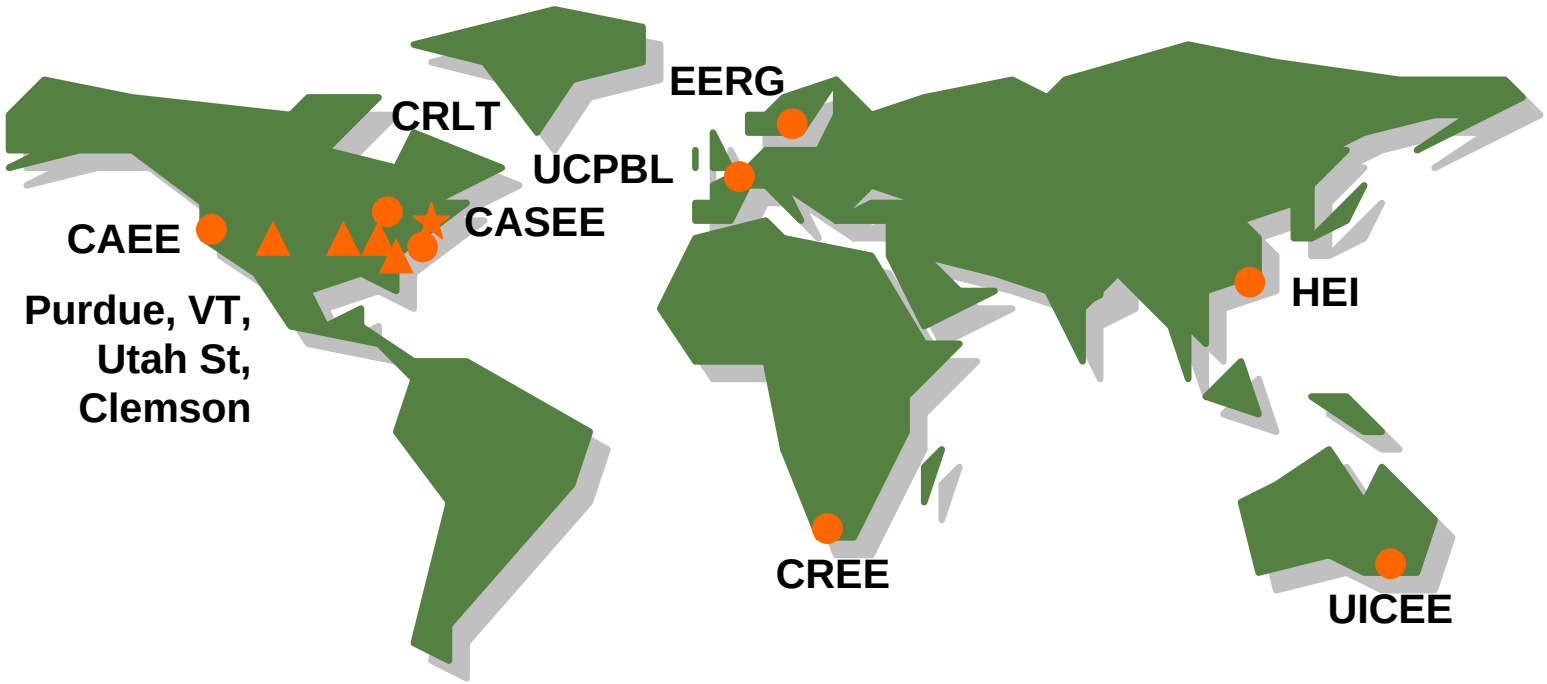
Building a global community

communities need support

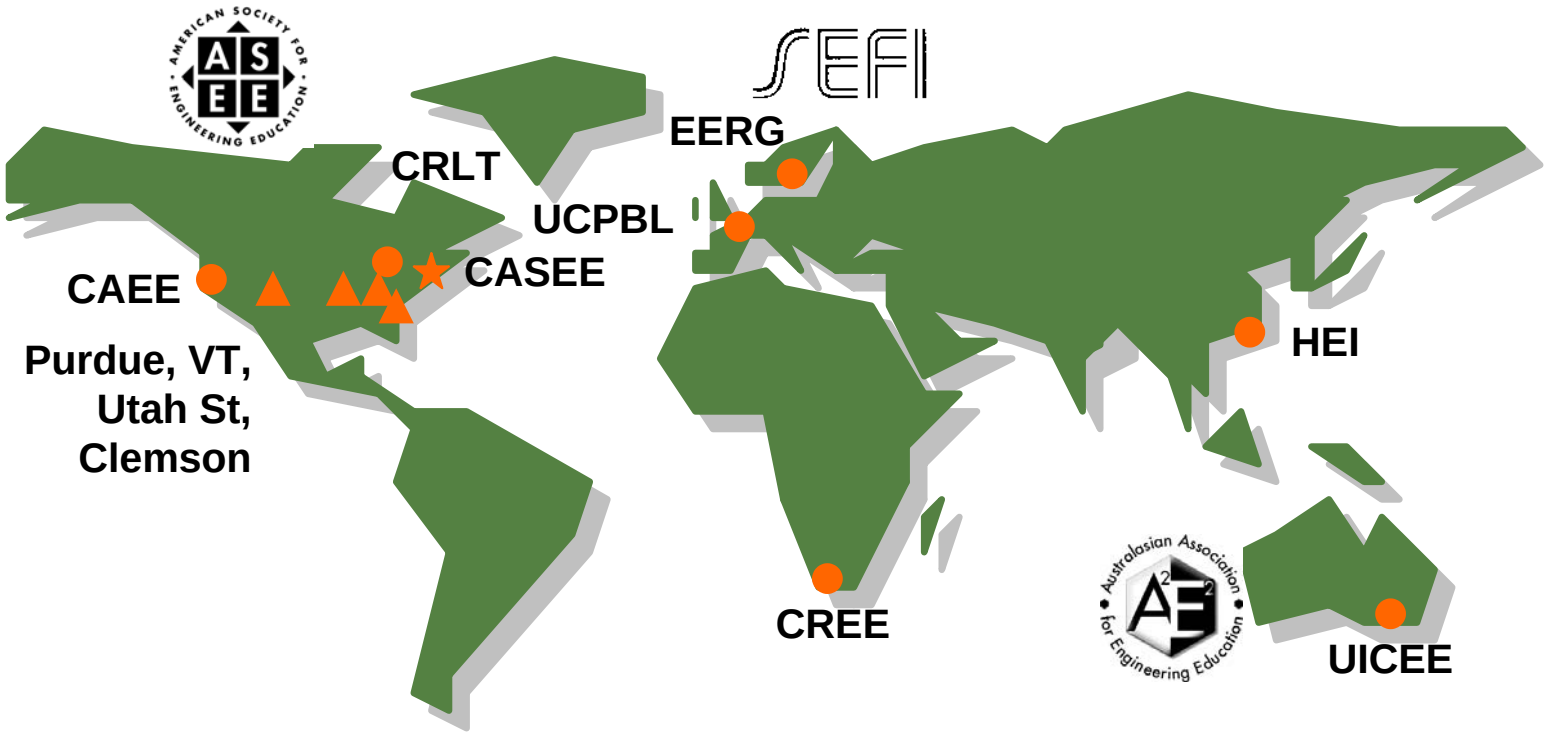
- Well-defined groups, centers, departments
- Supportive professional organizations and recognitions
- Adequate resources for basic research
- Quality forums for disseminating knowledge

Disclaimer: The following is a very limited set of examples of global developments

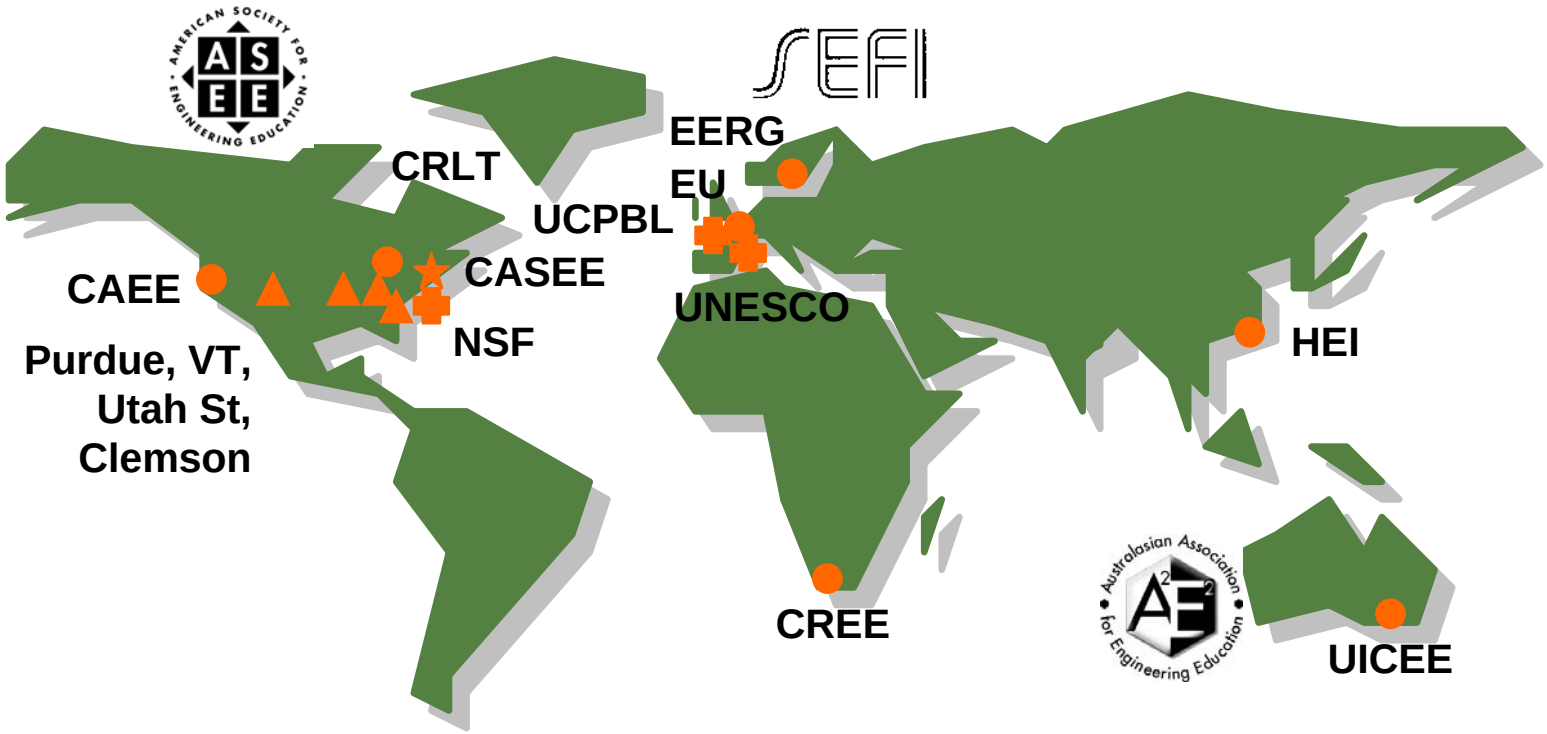
Well defined groups, centers, departments…



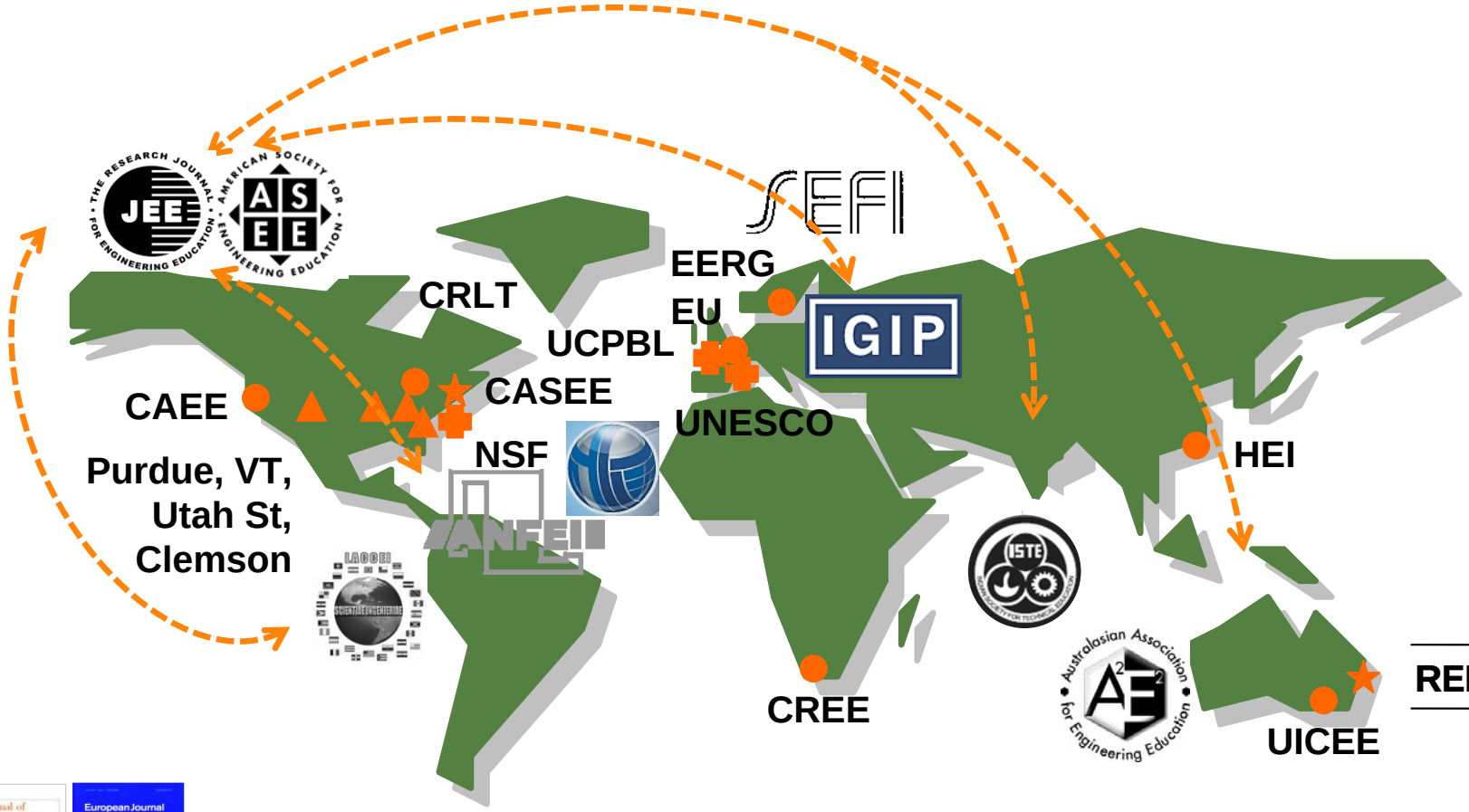
…supportive professional societies…



…support for basic research…



...forums for dissemination



"Advancing the Global Capacity for Engineering Education Research"
(Australia, Brazil, China, Denmark, Hungary, India, Russia, So. Africa, Turkey, USA)

Bottom line: You have a lot of company…and opportunities!

Rigorous Research in Engineering Education (RREE1)

- Summer Workshop - Initial event for year-long project
- Funded by NSF for 3 years, 2004-2006
- About 150 engineering faculty participated
- Presenters and evaluators representing
  - American Society for Engineering Education (ASEE)
  - American Educational Research Association (AERA)
  - Professional and Organizational Development Network in Higher Education (POD)

Rigorous Research in Engineering Education (RREE1)

- Faculty funded by two NSF projects:
- Conducting Rigorous Research in Engineering Education (NSF DUE-0341127)
- Strengthening HBCU Engineering Education Research Capacity (NSF HRDF-041194)
  - Council of HBCU Engineering Deans
  - Center for the Advancement of Scholarship in Engineering Education (CASEE)
  - National Academy of Engineering (NAE)

RREE1 Goals

- Identify engineering faculty interested in conducting engineering education research
- Develop faculty knowledge and skills for conducting engineering education research (especially in theory and research methodology areas)
- Cultivate the development of a Community of Practice of faculty conducting engineering education research

Engineering Education Research – Closing the Loop

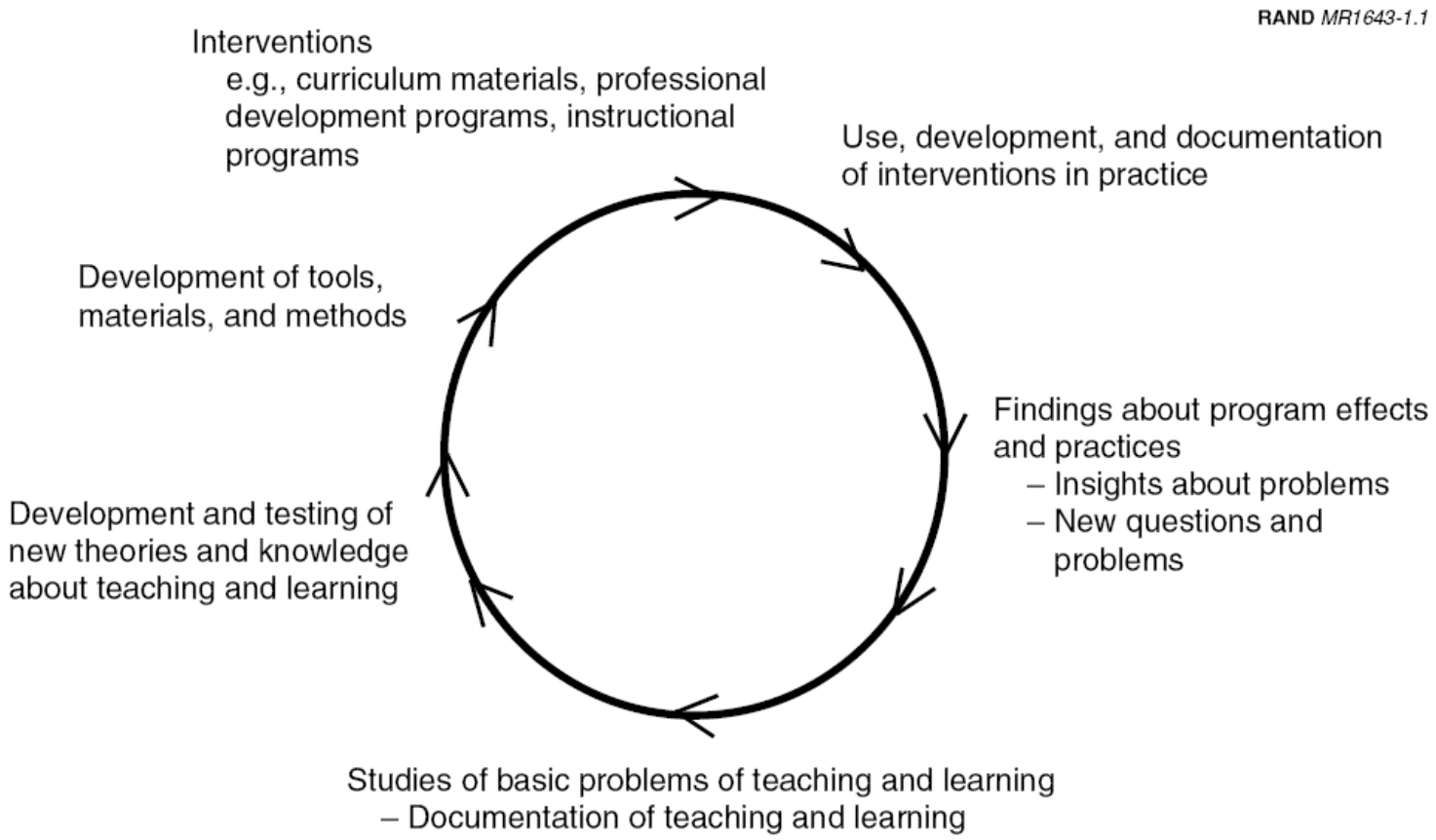


Figure 1.1—Cycle of Knowledge Production and Improvement of Practice

Mathematical Proficiency for All Students

Toward a Strategic Research and Development Program in Mathematics Education

RAND Mathematics Study Panel
Deborah Loewenberg Ball, Chair

Prepared for the
Office of Educational Research and Improvement (OERI)
U.S. Department of Education

Science & Technology Policy Institute RAND EDUCATION

Objectives for today's Workshop

1. Compare and contrast **technical** engineering and engineering **education** research

2. Begin to construct **globally-authored** definitions of rigorous engineering education research

Engineering Research

What are the guiding principles for rigorous technical research in your engineering discipline?

Technical engineering research can be called rigorous when….

→Take a few moments individually to list the qualities and characteristics of rigorous research in engineering.

→As a group, develop a list of research standards in engineering.

Technical (Engineering) Research

- Clear **objectives**
- Contextual
- Peer reviewed
- Defined methodology
- Theoretical foundation
- Broad based & sharp tipped
- Variables identified
- Sources of error identified
- Repeatable/testable
- Generalizable/transferrable/scalable
- Usually quantitative
- Clear conclusions based on findings
- Believable/credible
- Objective/unbiased
- **Builds on former results/former information**
- Assumption identified
- Calculations correct
- Method is methodological and appropriate
- Innovative/creative
- Reachable by appropriate audience
- Significance of research contribution
- Continuous improvement of results
- **Relevant and impactful**
- **Advances knowledge**
- **Cutting edge**
- Impactful on society & development of next technology
- Defendable
- **Grounded in theory**
- Complete and comprehensive both in documentation and research methods
- Novel
- SMART – specific, measurable, achievable, realistic & time-bounded
- Efficiency
- Interdisciplinary
- Short comings and limitations are noted
- **Relevant/practical**
- Validation – practically and statistically
- Multi-disciplinary
- Sustainable

Engineering Education Research Differences from engineering research

- More difficult to generalize, e.g., between cultures, laws, surroundings, backgrounds
- Applied to people/ social sciences
- Quantitative & qualitative
- Human oriented – softer
- Results & future results more difficult to measure and verify
- More difficult to execute the actions of the process because of unpredictable human interactions
- Ethical consideration
- Depends on research question
- Research needs to be carefully designed from the beginning
- Results are not always quantifiable
- People and bias issues
- Ensuring you have a representative sample (lots of conversations about N)
- Outcomes of research in eng ed is improving the quality of eng ed in terms of pedagogy, epistemology
- More adaptable
- More future oriented
- Need a lot more exposure, e.g., need to go to more sites
- Results are more open to interpretation
- It is credible as opposed to verifiable/repeatable
- Demand should drive an investment of time and effort in research, e.g, faculty demanding new teaching approaches, ABET, NAE, employer, advisory board

Education Research

What are the guiding principles for rigorous research in engineering education?

Engineering education research can be called rigorous when….

→Take a few moments individually to list the qualities and characteristics of rigorous engineering education research.

→As a group, develop a list of research standards in engineering education research.

Guiding Principles for Scientific Research in Education

1. **Question**: pose ***significant*** question that can be investigated ***empirically***
2. **Theory**: link research to relevant theory
3. **Methods**: use methods that permit direct investigation of the question
4. **Reasoning**: provide coherent, explicit chain of reasoning
5. **Replicate and generalize** across studies
6. **Disclose** research to encourage professional scrutiny and critique

National Research Council, 2002

Reactions & Comparisons

- How does the list generated compare with the NRC Six?
  - Similarities
  - Differences
- Is a global list possible or is the list dependent on the cultural context and research traditions

1. Significant questions that can be investigated empirically

- **Who would care about your results?**
- **What data will you need to gather to answer your question?**

2. Link research to relevant theory

- **Learning theories**
  - **Cognition**
  - **Novice – expert differences**
  - **Instructional psychology**
  - **Psychometrics**
- **Motivational theories**
- **Moral and ethical development**
- **Social context of education**

3. Methods for direct investigation (examples)

Quantitative methods

- Tests
- Surveys & questionnaires (defined response)
- Faculty or peer ratings

Qualitative methods

- Focus groups
- Interviews
- Observations

4. Reasoning

What makes a convincing argument

- Builds on what others have done before (literature)
- Theoretical foundation – make sense of results within existing frameworks of learning and teaching
- Methodology is explicit and appropriate
  - Instruments are reliable and valid
- Strength of observed relationships
- Elimination of alternative explanations
  - Study design
  - Confounding variables

5. Replicate and generalize – use the results

Setting the results in a larger context

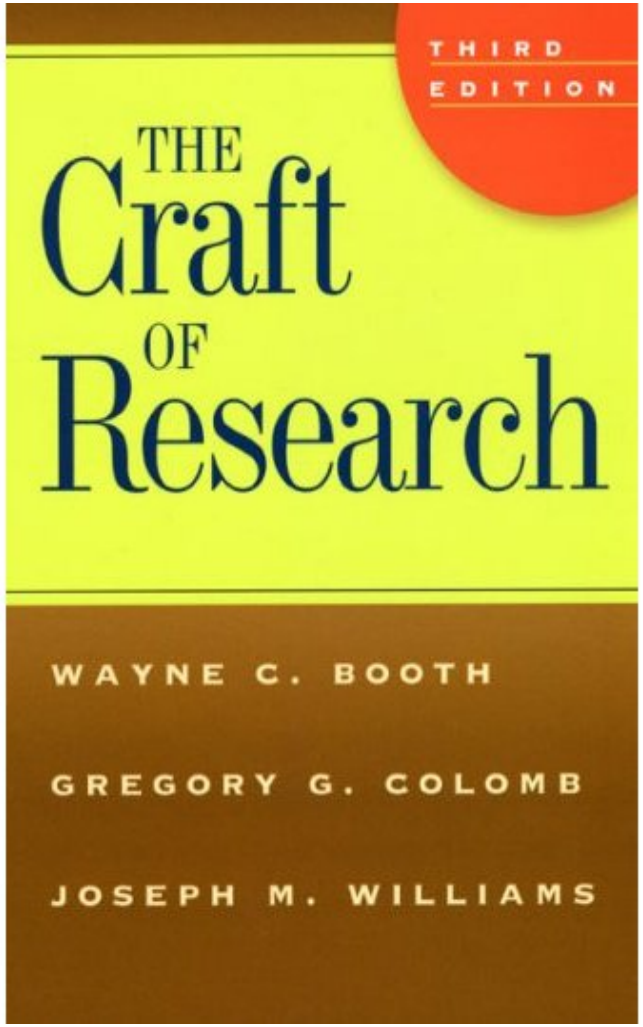
- **MUST know the literature**
- **Strict *replication* is rare in educational research**
  - ***Transferable* with extension - to new topic, setting, learners, etc.**

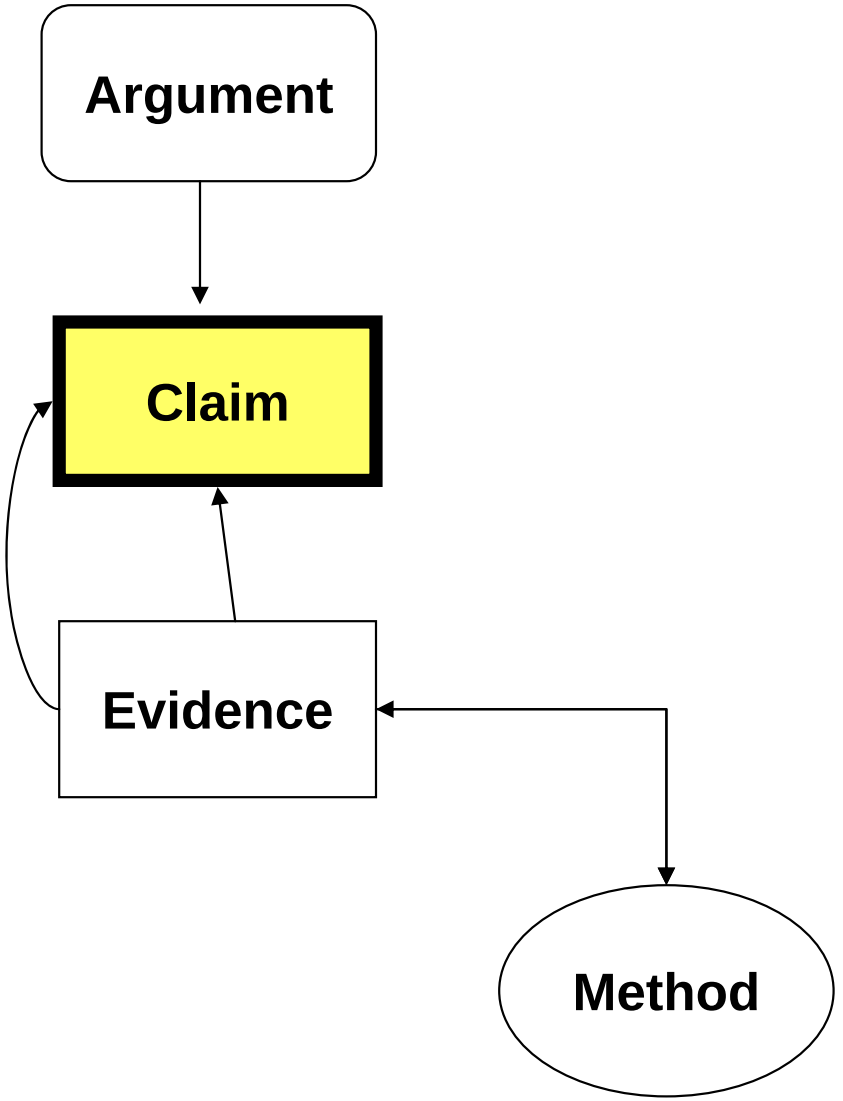
6. Disclose

- **Scholarly journals**
- **Conference presentations**

- **Peer-review is the core issue**
  - **One of the few quality controls we have**

The Craft of Research, 2008





What's next?

- Follow-up proposal (RREE2) has been awarded
  - Will include a series of 5 short courses
    - *Fundamentals of Educational Research*
    - *Identifying Theoretical Frameworks*
    - *Designing Your Research Study*
    - *Collaborating with Learning and Social Scientists*
    - *Understanding Qualitative Research*
  - Will be available on rreeHUB.org

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