Fundamentals of Engineering Education Research

Rigorous Research in Engineering Education Initiative
(NSF DUE 0817461)
https://stemedhub.org/groups/cleerhub

Texas State University – San Marcos – June 7, 2017

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A Workshop on

Building Capability and Communities in Engineering Education Research

sponsored by the

National Science Council

National Ping Tung University of Science and Technology

Meiho Institute of Technology

in partnership with

Annals of Research in Engineering Education

Journal of Engineering Education

Rigorous Research in Engineering Education Initiative

Kaohsiung—Taipei, Taiwan • 2-5 February 2009

Jack R. Lohmann
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Overview

What are we going to do?

- **Welcome and introductions**
- **Topics of the workshop**
  - Background and context
  - Features of engineering education research
  - Research questions and methodologies
  - Print and online resources
  - Global communities and their networks
- **Format of the workshop**
  - Interactive and team-based work

Who's here?

- **Your workshop leaders**
- **Introduce yourself to those near you**

Engineering Education Research and/or Innovation STORY

- When and how did you become interested in engineering education research and/or innovation?
- Was there a critical incident or memorable event associated with your initial interest?

Background and Context

Workshop frame of reference

- **Workshop is about**
  - Identifying faculty interested in engineering education research
  - Deepening understanding of engineering education research
  - Building engineering education research capabilities
- **Workshop is NOT about**
  - Pedagogical practice, i.e., "how to teach"
  - Convincing you that good teaching is important
  - Writing engineering education research grant proposals or papers
  - Advocating all faculty be engineering education researchers

Levels of inquiry in engineering education

- **Level 0** Teacher
  - Teach as taught
- **Level 1** Effective Teacher
  - Teach using accepted teaching theories and practices
- **Level 2** Scholarly Teacher
  - Assesses performance and makes improvements
- **Level 3** Scholar of Teaching and Learning
  - Engages in educational experimentation, shares results
- **Level 4** Engineering Education Researcher
  - Conducts educational research, publishes archival papers

Source: 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.

Workshop Intentions / Participant Learning Outcomes

1. Describe key features of engineering education research
2. Explain emergence of engineering education research as a discipline
3. Describe recent reports and their relevance for and relationship with engineering education research
4. Summarize growth of engineering education research
5. Speculate on the future of engineering education research

Some history about this workshop

- **Rigorous Research in Engineering Education (RREE1)**
  - One-week summer workshop, year-long research project
  - Funded by National Science Foundation (NSF), 2004-2006
  - About 150 engineering faculty participated
- **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)
  - Cultivate the development of a Community of Practice of faculty conducting engineering education research

RREE Approach

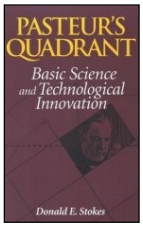
Theory
(study grounded in theory/conceptual framework)

Research that
makes a difference . . .
in theory and practice

Research
(appropriate design and methodology)

Practice
(implications for teaching)

Research can be inspired by …



Understanding (Basic)

	Use (Applied): No	Use (Applied): Yes
Yes	Pure basic research (Bohr)	Use-inspired basic research (Pasteur)
No		Pure applied research (Edison)

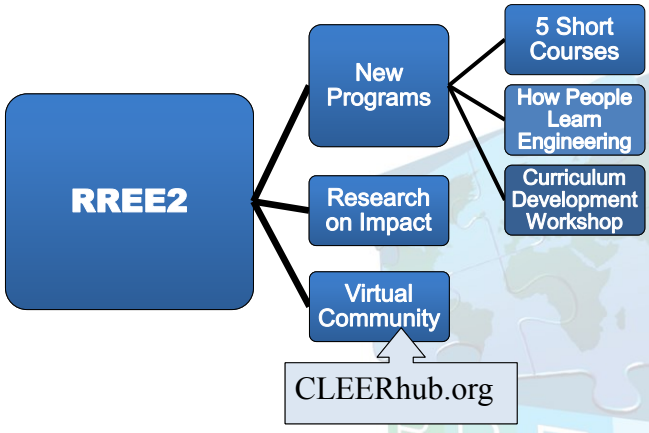
Source: Stokes, D. 1997. Pasteur's quadrant: Basic science and technological innovation. Washington, DC: Brookings Institution.

RIGOROUS RESEARCH in ENGINEERING EDUCATION

Funded by the National Science Foundation through awards DUE 0341127 and DUE 0817461

Expanding and sustaining research capacity in engineering and technology education: Building on successful programs for faculty and graduate students

Collaborative partners: Purdue (lead), Alverno College, Colorado School of Mines, Howard University, Madison Area Technical College, National Academy of Engineering



RIGOROUS RESEARCH in ENGINEERING EDUCATION

RREE2

Follow-up proposal (RREE2)

- Includes a series of 5 short courses*
  - Fundamentals of Engineering Education Research
  - Selecting Conceptual Frameworks
  - Understanding Qualitative Research
  - Designing Your Research Study
  - Collaborating with Learning and Social Scientists

*Recorded and posted on https://stemedhub.org/groups/cleerhub

Today's objectives

- Identify principal features of engineering education research
- Frame and situate research questions and methodologies
- Gain familiarity with several print and online resources
- Become aware of global communities and their networks

Objective 1

Identify principal features of engineering education research

What does high-quality research in your discipline look like?

- What are the **qualities, characteristics, or standards** for **high-quality** research in your discipline?
- Think of it this way: "**Research in my field is high-quality when….**"

☞ Individually, list the qualities, characteristics or standards in your discipline

☞ Compare your lists, and as a group, develop a list of high-quality research qualities, characteristics or standards

What does high-quality research in your discipline look like?

- (Workshop list)
- (Workshop list)

What does <u>education</u> research in your discipline look like?

- What are the **qualities, characteristics, or standards** for **high-quality <u>education</u>** research in your discipline?

☞ Individually, list:

1) Which qualities, characteristics, or standards identified in the previous list DO NOT apply?
2) What qualities, characteristics, or standards can you envision that are DIFFERENT for education research?

☞ As a group, combine your lists.

Guiding principles for scientific research in education

1. Pose **significant questions** that can be investigated **empirically**
2. Link research to relevant **theory**
3. Use **methods** that permit **direct investigation** of the question
4. Provide coherent, explicit chain of **reasoning**
5. Replicate and **generalize** across studies
6. Disclose research to encourage professional **scrutiny and critique**

- **How do our lists compare with the NRC six?**
- **Is a global list possible? Do cultural contexts matter?**

Source: Scientific Research in Education, National Research Council, 2002

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 research process and reasoning

Objective 2

Frame and situate research questions and methodologies

Most common frameworks in educational research

- **Theories of learning**
- **Theories of motivation**
- **Theories of development**
- **Theories of contextual effects**

See Marilla Svinick's Handbook — A Guidebook On Conceptual Frameworks For Research In Engineering Education.
https://stemedhub.org/collections/post/254/download/Conceptual_Frameworks_Revised_2010.pdf

Multiple theoretical frameworks

Which comes first: framework or observation?

Can go in either direction

Multiple theoretical frameworks

Going from framework to research question to research study

Framework

Self-determination framework says - students' motivation for a task is affected by the degree of control they have over it.

Therefore

If we manipulate the degree of student control, we should see variations in motivation levels.

Design

Different groups are given different degrees of control over the topic and process of their project and their motivation for the project is measured at various times throughout the semester.

Multiple theoretical frameworks

Going from observation to framework to research question to research study and back to observation

Observation

Some students in a class participate more than others.

Possible Frameworks

•Learning theory: Prior knowledge differences
•Motivation theory: Goal orientations, task value, self-efficacy
•Contextual variables: Course contingencies; classroom climate

Design possibilities

•Measure and regress level of participation on potential variables.
•Manipulate course contingencies or course practices.

What is your experience?

- Silently reflect on your experience with engineering education research
- Jot down
  - What has been the most exciting opportunity for you in this area?
  - What has been the most difficult challenge you have faced?
- Share with the person next to you

Objective 3

Gain familiarity with several print and online resources

Books, journals, online resources

- The Craft of Research
- Scientific Research in Education
- Journal of Engineering Education (JEE)
- Science Citation Index
- Some other journals

VIEW EDIT

Engineering Education Departments and Programs (Graduate)

(redirected from Engineering-Education-Degree-and-Certificate-Programs)

last edited by Elliot Douglas 2 months, 3 weeks ago

Page history

1. Engineering/STEM Education Graduate Programs
2. Engineering Education-Related Certificate Programs
3. Innovative Engineering and Inter/Cross-Disciplinary Programs

<Home

Engineering/STEM Education Graduate Programs

Institution	Program	Degrees Awarded
Arizona State University	Mary Lou Fulton Teachers College	M.Ed. Educational Technology Ph.D. in Curriculum and Instruction with concentration in Engineering Education (more info) Ph.D. in Educational Technology Ph.D. in Educational Technology with concentration in Arts, Media, and Engineering
	Ira A. Fulton School of Engineering	Ph.D. Aerospace Engineering with concentration in Engineering Education Ph.D. Mechanical Engineering with concentration in Engineering Education
University of California - Berkeley	Studies in Engineering, Science, and Mathematics (SESAME) Education	M.A. Technology, Science, or Math Education. Ph.D. Technology, Science, or Math Education
Chalmers University of Technology (Sweden)	Department of Applied Information Technology	Licentiate Engineering Education Research Ph.D. Engineering Education Research
University of Cincinnati	School of Engineering Education (SEE)	
Clemson University	Department of Engineering and Science Education	Ph.D. Engineering or Science Education
University of Kentucky	College of Education - Department of Science, Technology, Engineering and Mathematics	Ph.D. Science, Technology, Engineering and Mathematics Education
Linköping University (Sweden)	Engineering Education Research Group	Ph.D. Engineering Education Research
The College of New Jersey	School of Engineering - Department of Technological Studies	M.A.T. in Secondary Education - Technology Education
Niagara University	College of Education	M.S. Ed. Math, Science, and Technology Education
North Carolina State University	College of Education - Department of Science, Technology, Engineering, and Mathematics Education	M.S. and M.Ed. Program in Technology Education Ed.D. Program in Technology Education
Old Dominion University	Darden College of Education - Department of STEM Education & Professional Studies	M.S. Engineering - Modeling and Simulation

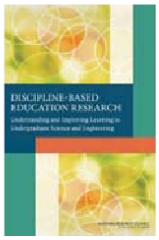
http://tinyurl.com/engredu

Global Calls for Reform

K-12 Engineering

Research-based Transformation

Discipline-Based Education Research (DBER)



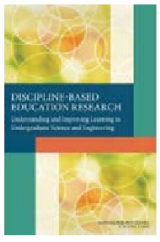
National Research Council 2012

- Discipline-based education research (DBER) is a **small but growing field of inquiry**.
- **Conducting DBER** and **using DBER** findings are **distinct but interdependent** pursuits.
- DBER is **inherently interdisciplinary.**
- Individual fields of DBER have made **notable inroads** in terms of establishing their fields **but still face challenges in doing so**.
- **Blending** a scientific/engineering discipline with education research poses **unique professional challenges for DBER scholars**.
- There are **many pathways to becoming a discipline-based education researcher**.

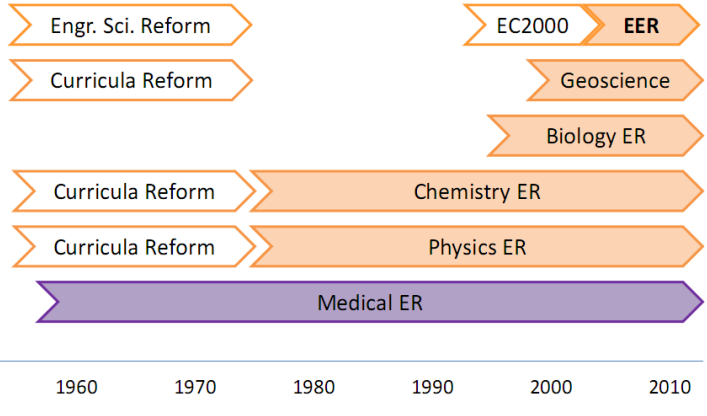
PURDUE ENGINEERING EDUCATION

Discipline-Based Education Research Timeline

DBER Departments and Graduate Programs



National Research Council 2012



PURDUE ENGINEERING EDUCATION

DBER is **located** in the relevant disciplinary school, e.g. medicine, physics.

SCIENCE EDUCATION AT THE NATIONAL RESEARCH COUNCIL
www.nationalacademies.org/bose

Discipline-Based Education Research (DBER)

Understanding and Improving Learning in Undergraduate Science and Engineering

http://www.nap.edu/catalog.php?record_id=13362

ASEE Reports - A Path Forward

Seven Recommendations for Innovation with Impact

Who

1. Grow professional development in teaching and learning.
2. Expand collaborations.

What

3. Expand efforts to make engineering more engaging, relevant, and welcoming.

How

4. Increase, leverage, and diversify resources for engineering teaching, learning, and innovation.
5. Raise awareness of proven practices and of scholarship in engineering education.

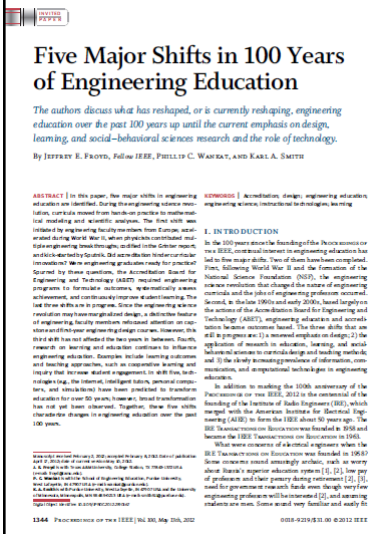
Seven Recommendations for Innovation with Impact *(continued)*

Creating a Better Culture

To measure progress in implementing policies, practices, and infrastructure in support of scholarly and systematic innovation in engineering education:

6. Conduct periodic self-assessments in our individual institutions.
7. Conduct periodic community-wide self-assessments.

https://www.asee.org/member-resources/reports/Innovation-with-Impact



Five Major Shifts in 100 Years of Engineering Education

The authors discuss what has reshaped, or is currently reshaping, engineering education over the past 100 years up until the current emphasis on design, learning, and social–behavioral sciences research and the role of technology.

By Jeffrey E. Froyd, *Fellow IEEE*, Phillip C. Wankat, and Karl A. Smith

1. a shift from hands-on and practical emphasis to engineering science and analytical emphasis;
2. a shift to outcomes-based education and accreditation;
3. a shift to emphasizing engineering design;
4. a shift to applying education, learning, and socialbehavioral sciences research;
5. a shift to integrating information, computational, and communications technology in education.

http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&tp=&arnumber=6185632

Objective 4

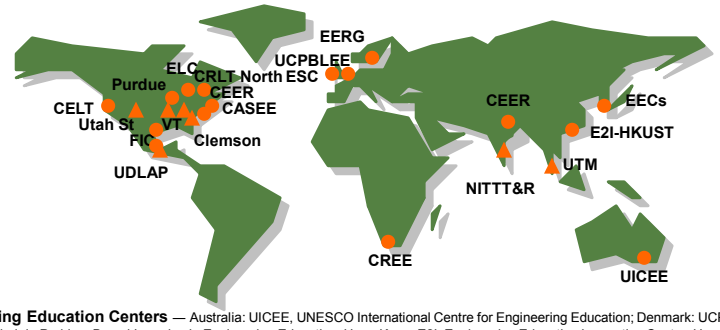
Become aware of global communities and their networks

An emerging global community

- Groups, centers, departments
- Engineering education societies
- Forums for dissemination

What follows is a **sample** — it is NOT an exhaustive list!

Groups, centers, departments…



● **Engineering Education Centers** — Australia: UICEE, UNESCO International Centre for Engineering Education; Denmark: UCPBLEE, UNESCO Chair in Problem Based Learning in Engineering Education; Hong Kong: E2I, Engineering Education Innovation Center, Hong Kong University of Science and Technology; Pakistan: Center for Engineering Education Research, NUST, National University for Science and Technology; South Africa: CREE, Centre for Research in Engineering Education, U of Cape Town; Sweden: Engineering Education Research Group, Linköping U; UK: ESC, Engineering Subject Centre, Higher Education Academy; USA: CELT, Center for Engineering Learning and Teaching, U of Washington; CRLT North, Center for Research on Learning and Teaching, U of Michigan; Faculty Innovation Center, U of Texas-Austin; Engineering Learning Center, U of Wisconsin-Madison; CASEE, Center for the Advancement of Scholarship in Engineering Education, National Academy of Engineering; EEIC, Engineering Education Innovation Center, Ohio State University; CEER, Center for Engineering Education Research, Michigan State University, EECs, Engineering Education Centers in Korea.

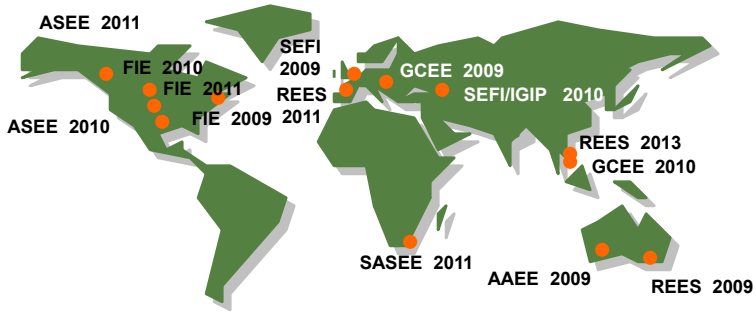
▲ **Engineering Education Degree-granting Departments** — USA: School of Engineering Education, Purdue U; Department of Engineering Education, Virginia Tech; Department of Engineering and Science Education, Clemson U; Department of Engineering and Technology Education, Utah State U; Malaysia: Engineering Education PhD program, Universiti Teknologi Malaysia; India: National Institute for Technical Teacher Training and Research; Mexico: Universidad de las Americas, Puebla

Engineering education societies…

Societies with Engineering Education Research Groups — ASEE, American Society for Engineering Education, Educational Research Methods Division; SEFI, Société Européenne pour la Formation des Ingénieurs (European Society for Engineering Education), Engineering Education Research Working Group; Australasian Association for Engineering Education, Engineering Education Research Working Group; Community of Engineering Education Research Scholars, Latin America and Caribbean Consortium for Engineering Institutions

Societies with Engineering Education Research Interests — Indian Society for Technical Education, Latin American and Caribbean Consortium of Engineering Institutions, Asociación Nacional de Facultades y Escuelas de Ingeniería (National Association of Engineering Colleges and Schools in Mexico), Internationale Gesellschaft für Ingenieurpädagogik (International Society for Engineering Education), International Federation of Engineering Education Societies, South African Engineering Education Association (SASEE)

Forums for dissemination…



Conferences with engineering education research presentations:

- **ASEE** — Annual Conference, American Society for Engineering Education, see www.asee.org
- **AAEE** — Annual Conference, Australasian Association for Engineering Education, see www.aaee.com.au
- **FIE** — Frontiers in Education, sponsored by ERM/ASEE, IEEE Education Society and Computer Society, /fie-conference.org/erm
- **GCEE** — Global Colloquium on Engineering Education, sponsored by ASEE and local partners where the meeting is held, see www.asee.org
- **SEFI** — Annual Conference, Société Européenne pour la Formation des Ingénieurs , see www.sefi.be
- **REES** — Research on Engineering Education Symposium, rees2009.pbwiki.com/
- **SASEE** – South African Society for Engineering Education,

Becoming an Engineering Education Researcher—Adams, Fleming & Smith

1. Find and follow your dream.
2. Find and build community.
3. Do your homework. Become familiar with engineering education research.
4. Remember what it is like to be a student—be open to learning and the associated rewards and challenges.
5. Find balance. You will feel like you have multiple identities.
6. Be an architect of your own career.
7. Wear your researcher "lenses" at all times.
8. Use research as an opportunity for reflective practice.

Adams, R., L. Fleming, and K. Smith. 2007. Becoming an engineering education researcher: Three researchers stories and their intersections, extensions, and lessons. Proceedings, International Conference on Research in Engineering Education; http://www.ce.umn.edu/%7Esmith/docs/Adams-Fleming-Smith-Becoming_an_engineering_education_researcher-ICREE2007.pdf

What Are Your Plans?

- Silently reflect on your interests and plans for applying and/or supporting engineering education research, or becoming an engineering education researcher.
- Jot down
  - What do you plan to do next?
  - What are your longer range plans?
- Share with the person next to you

Thank you!

An e-copy of this presentation will be posted to:
http://personal.cege.umn.edu/~smith/links.html

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